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AFML - TR - 68 - 026

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LIFE TEST OF AN EXTREMELY LONG LIFE TUNABLE ICEM[®] MAGNETRON

Supplement to Technical Report AFML-TR-68-168

P. Bahr

S-F-D laboratories, inc. Subsidiary of Varian Associates Union, New Jersey

TECHNICAL REPORT AFML-TR-68-326

September 1968

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> Air Force Materials Laboratory Air Force Systems Command Wright-Patterson Air Force Base, Ohio





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APML-TR-68-326

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FOREWORD

·. .

This supplementary technical report documents the results of the life test phase of Contract AF 33(615)-3183. The extended life testing began on 15 May 1967 and was concluded in August 1968. The contract with S-F-D isboratories, inc., Union, New Jersey, was initiated under Manufacturing Methods Project 8-283, "Development of Manufacturing Methods for Producing Long Life X-land ICEM[®] Magnetrons." It was accomplished under the technical direction of Captain William Horsfield of the Electronics Branch (MATE), Manufacturing Technology Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio.

The work was performed under the direction of Dr. G. K. Farney, Technical Director of S-F-D laboratories. W. R. Lundberg, Manager of Product Development and Manufactuling, was responsible for the performance of the contract. P. Bahr, Electrical Engineer, was responsible for the life test evaluation.

This document has been assigned S-F-D laboratories Report No. 67-FS.

The report was submitted by the author in September 1968.

This technical report has been reviewed and is approved.

WTTTERORT

Chief, Electronics Branch Manufacturing Technology Division

S·F·D laboratories, inc

1.0 INTRODUCTION

The manufacturing methods program, Contract AF 33(615)-3183, which resulted in the development of the SFD-328, required that the final report be written prior to completion of the extended life test phase of the program. Technical report AFML-TR-68-168^{*}, submitted by the authors in June 1968, described the program with the exception of the life test results. Life testing was concluded on 6 August 1968 with the failure of the life test tube.

This report contains the life test history and is a supplement to AFML-TR-68-168.

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S·F·D laboratories, inc.

2.0 LIFE TEST PROGRAM RESULTS

On 15 May 1967, extended life testing was begun on tube D14I. Initially, this tube satisfied all of the specification requirements under Quality Conformance Inspection Part I. The initial data can be seen in Table I. Tube D14I was the only production phase tube available at that point in the program.

In August 1967, the last tube built during this program was constructed. This tube, H53I, while meeting specification, was not a better tube than D14I. There were indications of internal dimension changes and it was decided that, even though the power output on D14I had fallen off, tube D14I had a better chance of completing 5000 hours life test than H53I.

Modulator reliability was very poor throughout the life test. Due to the intermittent nature of the modulator failures - i.e., the modulator would turn itself off for no assignable reason - it was impossible to obtain 24 hour operation. In an effort to alleviate this situation, all of the major modulator components were replaced. During the last five months of life testing, the modulator was operating 73.5% of available time.

Referring to Figure 1, it can be seen that there were two times when significant changes occurred to the output power of the life test tube. The first change took place during the first 200 hours of operation. This reduction of power, which was accompanied by a decrease in operating voltage, was attributed to movement of the cathode within the tube. This was followed by a period where only slight changes occurred. The output power measured at 2500 hours was about the same as that measured at 200 hours. Data taken between these two points are given in Tables I through VI.

The final electrical data, taken after 5015.6 hours on life test, are given in Table VII, with a power and voltage curve shown in Figure 2. Performance at this point was very poor, with power output at F_1 down to 54 kw. When the modulator was shut down to install the water

Serial No. Dl4I				Date 1	l May 1967	
	Limit	Ω.				
Test	Min	Max	Units		Resulus	
Dimensions					Xo	
Pressurization	45	١	psia		×	
Tuner torque	I	15	in-oz		< 10 in-0	N
Heater current, $E_f = 23 v$	8	10	sdus		9.2 ampis	
Warm-up time	·	300	8 e c		Хo	
Operating Tests Osc (1)						
$t_{pc} = 2.5 \ \mu sec nom$	Du = 0.001	ц Ч	60 ma dc			
Test frequency				۳1	F 3	F F
Pulse voltage	23	27	kv	24.8	25.7	26.3
Power output	400	ı	я	450	483	415
RF bandwidth	I	2.4/t.5	MHz	0.430	0.500	0.400
Spectrum minor lobes	8	1	qp	12	11	12
Stability	ı	0.5	.9 8-	0.004	0.02	0.004
Tunable frequency	F5 + 25	F ₁ - 25	MHz	8549	I	9655

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QUALITY CONFORMANCE INSPECTION PART I

s**fd-**328

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TUBE PERFORMANCE PRIOR TO START OF LIFE TEST TABLE I

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INTERMITTENT LIFE TEST END POINT DATA SHEET

SFD-328

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ير بير 295 Date 23 June 1967 Results e س 320 335 с. Г. 8 Units Life test time to date 199 hours MHz qp 3 R 2.5/t_{pc} Max 1.0 ; Limits MIn 320 I 6 0sc (1) Modulator No. 456-2 Spectrum side lobes Serial No. D141 Power output RF bandwidth Test Stabilıty

2

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TABLE II TUBE PERFORMANCE AFTER 199 HOURS OF LIFE TEST

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SFD-328

Serial No. Dl41	Life test time t	o date 469 h	NULN	Date	901 VINC G	
Medulater No. 456-2	G&c (1)					
	111	mits			Kenulen	
Test	M1n	Max	Und te	- 	بر بر	ъ. Т
Power output	320	1	3	315	. 90:	
RF handwidth	ı	2.5/t.	#H#		•	•
Spectrum side lobes	6		qp	ı	ĩ	:
Stability	ı	1.0	¥	ı	•	•

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TABLE 111 TUBE PERFORMANCE AFTER 469 HOURS OF LIFE TEST

Serial No. Dl4I Modulator No. 456-2	Life test time Osc (1)	to date 102	8 hours	Date	29 Augunt]	1961
		Limits			Results	
Test	Min	Max	Units	F,	r L	ل ا ر
Power output	320	·	3	295	320	280
RF bandwidth	·	2.5/t _{bc}	MHz	0.60	0.65	0.52
Spectrum side jobes	9		qp	11.0	10.0	12.3
Stability	\$	1.0	₽ 8 e	0.02	0.0	0.0

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INTERMITTENT LIFE TEST END POINT DATA SHERT

SFD-328

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TABLE IV TUBE PERFORMANCE AFTER 1028 HOURS OF LIFE TEST

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	SFD	- 328				
Serial No. Dl4I	Life test time	to date 1800	hours	Date	12 January	1968
Modulator No. 456-2	0sc (1)					
	н	inits			Results	
Test	<u>M1n</u>	Max	<u>Units</u>	I 4	بن بند	н С
Power output	320	ł	3	262	390	325
RF bandwidth	I	2.5/t _{pc}	MHz	3	ı	t
Spectrum side lobes	9	١	db	ı	ł	ŧ
Stability	•	0.1	R	ı	ı	ł
TABLE V	TUBE PERFORMA	NCE AFTER 180	O HOURS OF LI	FE T'ST		

INTERMITTENT LIFE TEST END POINT DATA SHEET

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SHEET	
DATA	
POINT	
END	328
TEST	SFD-:
LIFE	
INTERMITTENT	

ce 14 March 1968		Results	F3 F5
Dat			1 1 1
e 2500 hours			lax Unit
sst time to date		Limits	MIn
Life te	2 0sc (1)		
Serial No. Dl4I	Modulator No. 456-2		Test

TEST
LIFE
0F
HOURS
2500
AFTER
PERFORMANCE
TUBE
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TABLE

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R

1.0

0.6 1?.0

0.6 11.0

0.55 12.5

MHz

2.5/t_{pc}

1

qp

ı

9

Spectrum side lobes

Stability

300

333

300

3

1

320

9

Power output

RF bandwidth

Serial No. Dl4I	Life test time t	o date 5015	.6 hours	Date	6 August	1968
Modulator No. 456-2	Osc (1))	
		mite			Results	
Test	Min	Max	Units	F1	ۍ هر	ц Ри
Power output	320	ı	3	54	206	128
RF bardwidth	ı	2.5/t _{bc}	MHz	r	5.4	2.4
Spectrum side lobes	9	8	đb	8	ω	တ
Stabj lity	I	1.0	R	ı	0.3	0.001

INTERMITTENT LIFE TEST END POINT DATA SHEET

SPD-328

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TABLE VII FINAL ELECTRICAL DATA AFTER 5015.6 HOURS OF LIFE TEST

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S•F•D laboratories, inc.

load, the tube was operating at F_5 . After the water load was installed and the tube frequency was changed, the RF pulse began to shorten and some arcing occurred. An increase in modulator inverse current caused the modulator high voltage interlock to open. Attempts to restart the tube at the normal 2.4 µsec pulse length failed, and the tube was finally operated at a pulse length of 0.5 µsec. Because of moding and generally poor performance at F_1 , the life test end points of bandwidth, side lobe ratio, and stability were not obtainable.

S·F·D laboratories, inc.

3.0 CONCLUSIONS

The reason for severe degradation appears to be a combination of cathode movement and cathode poisoning. It is known that the electron space charge or spoke of a magnetron changes shape as the tube frequency is changed. When the tube was tuned from F_5 , the areas of bombardment on the anode changed. The new areas could possibly have become saturated with vaporization products from the anode or other hot areas of the cathode assembly and when localized heating took place, these products were rapidly released. This then caused some arcing which created more localized pressure increases and more arcing. The severe arcing resulted in cathode poisoning and loss of RF output. Attempts to reactivate the cathode were unsuccessful, and the final performance of the tube is in agreement with Table VII and Figure 2.

Thermal stress produced by the arcing could also have caused a permanent dimensional change of either anode, cathode or end hats, which contributed to the complete failure of the device.

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Security Classification			
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800 Rahway Avenue		UN.	classified
Union, New Jersey			
J. REPORT TITLE			
LIFE JEST OF AN EXTREMELY LONG LIFE TUNABLE	E ICEM [®] MAGNI	LIKUN	
Supplement to Technical Report AFML-TR-68-	168		
4. DESCRIPTIVE NOTES (Type of report and inclusive doise) Supplement to Technical Provet ATME-TP-68-	168 (45 000	901)	
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13. ABSTRACT			
The manufacturing methods program required that the final report be delivere The SFD-328 accumulated over 5000 hours of which terminated the test. This report presents the results possible reasons for the failure of the li	under which d prior to c life test t of the life fe test vehi	this tube ompletion ime prior test progr cle.	e was developed of the life test. to failure, am, and indicates

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