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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
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APML-TR-68-126

September 1968

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FOREWORD

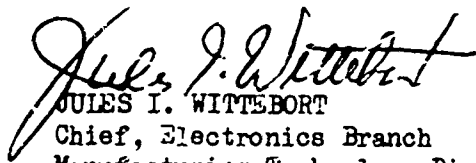
This supplementary technical report documents the results of the life test phase of Contract AF 33(615)-3183. The extended life testing began on 15 May 1967 and was concluded in August 1968. The contract with S-F-D laboratories, inc., Union, New Jersey, was initiated under Manufacturing Methods Project 8-283, "Development of Manufacturing Methods for Producing Long Life X-band 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 Manufacturing, 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.


JULES I. WITTEBORT
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.

* AD 838 801

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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

QUALITY CONFORMANCE INSPECTION PART I

SFD-328

Serial No. D141

Date 1 May 1967

<u>Test</u>	<u>Limits</u>		<u>Units</u>	<u>Results</u>
	<u>Min</u>	<u>Max</u>		
Dimensions				
Pressurization	45	-	psia	OK
Tuner torque	-	15	in-oz	OK
Heater current, $E_f = 23$ v	8	10	amps	< 10 in-oz
Warm-up time	-	300	sec	9.2 amps
				OK

Operating Tests Osc (1)

$t_{pc} = 2.5$ μ sec nom $D_u = 0.001$ $I_b = 60$ ma dc

Test frequency	F_1	F_3	F_5
Pulse voltage	24.8	25.7	26.3
Power output	450	483	415
RF bandwidth	0.430	0.500	0.400
Spectrum minor lobes	12	11	12
Stability	0.004	0.02	0.004
Tunable frequency	8549	-	9655
	$F_5 + 25$	$F_1 - 25$	

TABLE I TUBE PERFORMANCE PRIOR TO START OF LIFE TEST

SFD-328 Tube D14I

□ P_1
 △ P_3
 ○ P_5

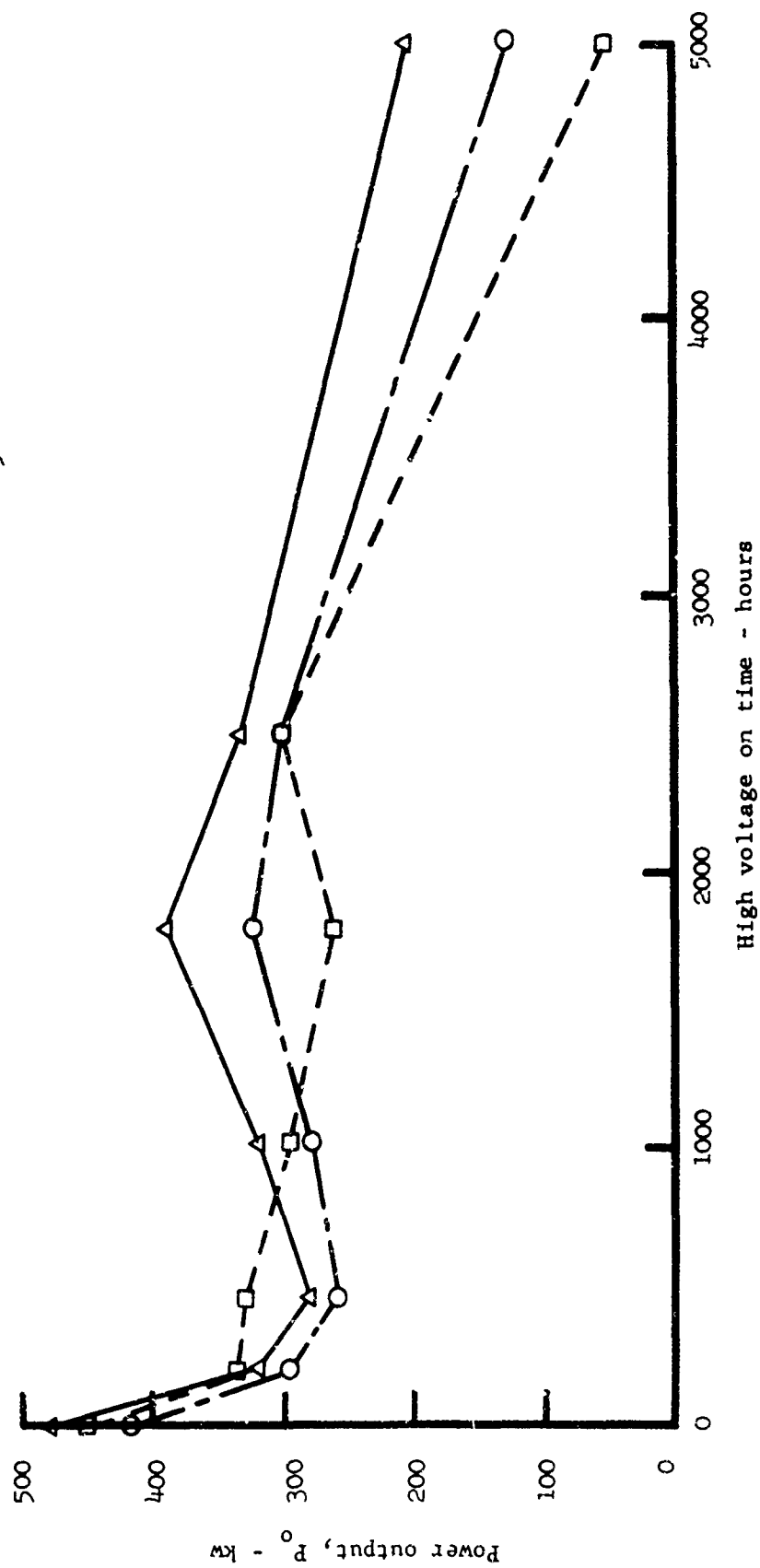


FIGURE 1 LIFE TEST POWER CURVE

INTERMITTENT LIFE TEST END POINT DATA SHEET

SFD-328

Serial No. D14I Life test time to date 199 hours Date 23 June 1967
 Modulator No. 456-2 Osc (1)

Test	Limits			Results		
	Min	Max	Units	F ₁	F ₃	F ₅
Power output	320	-	w	335	320	295
RF bandwidth	-	2.5/t _{pc}	MHz	-	-	-
Spectrum side lobes	6	-	db	-	-	-
Stability	-	1.0	φ	-	-	-

TABLE II TUBE PERFORMANCE AFTER 199 HOURS OF LIFE TEST

INTERMITTENT LIFE TEST END POINT DATA SHEET

SFD-328

Serial No. D14I Life test time to date 469 hours Date 3 July 1967
 Modulator No. 456-2 Osc (1)

<u>Test</u>	<u>Limits</u>		<u>Results</u>			
	<u>Min</u>	<u>Max</u>	<u>Units</u>	<u>F₁</u>	<u>F₃</u>	<u>F₅</u>
Power output	320	-	w	315	280	260
RF bandwidth	-	2.5/ε	MHz	-	-	-
Spectrum side lobes	6	-	db	-	-	-
Stability	-	1.0	%	-	-	-

TABLE III TUBE PERFORMANCE AFTER 469 HOURS OF LIFE TEST

INTERMITTENT LIFE TEST END POINT DATA SHEET

SFD-328

Serial No. D14I Life test time to date 1028 hours Date 29 August 1967
 Modulator No. 456-2 Osc (1)

<u>Test</u>	<u>Limits</u>			<u>Results</u>				
	<u>Min</u>	<u>Max</u>	<u>Units</u>	<u>F₁</u>	<u>F₃</u>	<u>F₅</u>		
Power output	320	-	w	295	320	280		
RF bandwidth	-	2.5/t _{pc}	MHz	0.60	0.65	0.52		
Spectrum side lobes	6	-	db	11.0	10.0	12.3		
Stability	-	1.0	%	0.02	0.0	0.0		

TABLE IV TUBE PERFORMANCE AFTER 1028 HOURS OF LIFE TEST

INTERMITTENT LIFE TEST END POINT DATA SHEET

SFD-328

Serial No. D14I Life test time to date 1800 hours Date 12 January 1968
 Modulator No. 456-2 Osc (1)

<u>Test</u>	<u>Limits</u>			<u>Results</u>		
	<u>Min</u>	<u>Max</u>	<u>Units</u>	<u>F₁</u>	<u>F₃</u>	<u>F₅</u>
Power output	320	-	w	262	390	325
RF bandwidth	-	2.5/t _{pc}	MHz	-	-	-
Spectrum side lobes	6	-	db	-	-	-
Stability	-	1.0	%	-	-	-

TABLE V TUBE PERFORMANCE AFTER 1800 HOURS OF LIFE TEST

INTERMITTENT LIFE TEST END POINT DATA SHEET

SFD-328

Serial No. D14I	Life test time to date	2500 hours	Date	14 March 1968
Modulator No. 456-2	Osc (1)			
<u>Test</u>	<u>Limits</u>		<u>Results</u>	
	<u>Min</u>	<u>Max</u>	<u>Units</u>	
Power output	320	-	w	
RF bandwidth	-	2.5/t _{pc}	MHz	
Spectrum side lobes	6	-	db	
Stability	-	1.0	%	
			F ₁	F ₃
			300	333
			0.55	0.6
			12.5	11.0
			0.01	0.00
				F ₅
				300
				0.6
				12.0
				0.00

TABLE VI TUBE PERFORMANCE AFTER 2500 HOURS OF LIFE TEST

INTERMITTENT LIFE TEST END POINT DATA SHEET

SFD-328

Serial No. D14I Life test time to date 5015.6 hours Date 6 August 1968
 Modulator No. 456-2 Osc (1)

<u>Test</u>	<u>Limits</u>			<u>Results</u>				
	<u>Min</u>	<u>Max</u>	<u>Units</u>	<u>F₁</u>	<u>F₃</u>	<u>F₅</u>		
Power output	320	-	w	54	206	128		
RF bandwidth	-	2.5/t _{pc}	MHz	-	2.4	2.4		
Spectrum side lobes	6	-	db	-	8	8		
Stability	-	1.0	%	-	0.3	0.001		

TABLE VII FINAL ELECTRICAL DATA AFTER 5015.6 HOURS OF LIFE TEST

Tube D14I

Power output after 5000 hours life test

$i_b = 60 \text{ a}$

$Du = 0.0005$

$t_{pc} = 0.5 \text{ } \mu\text{sec}$

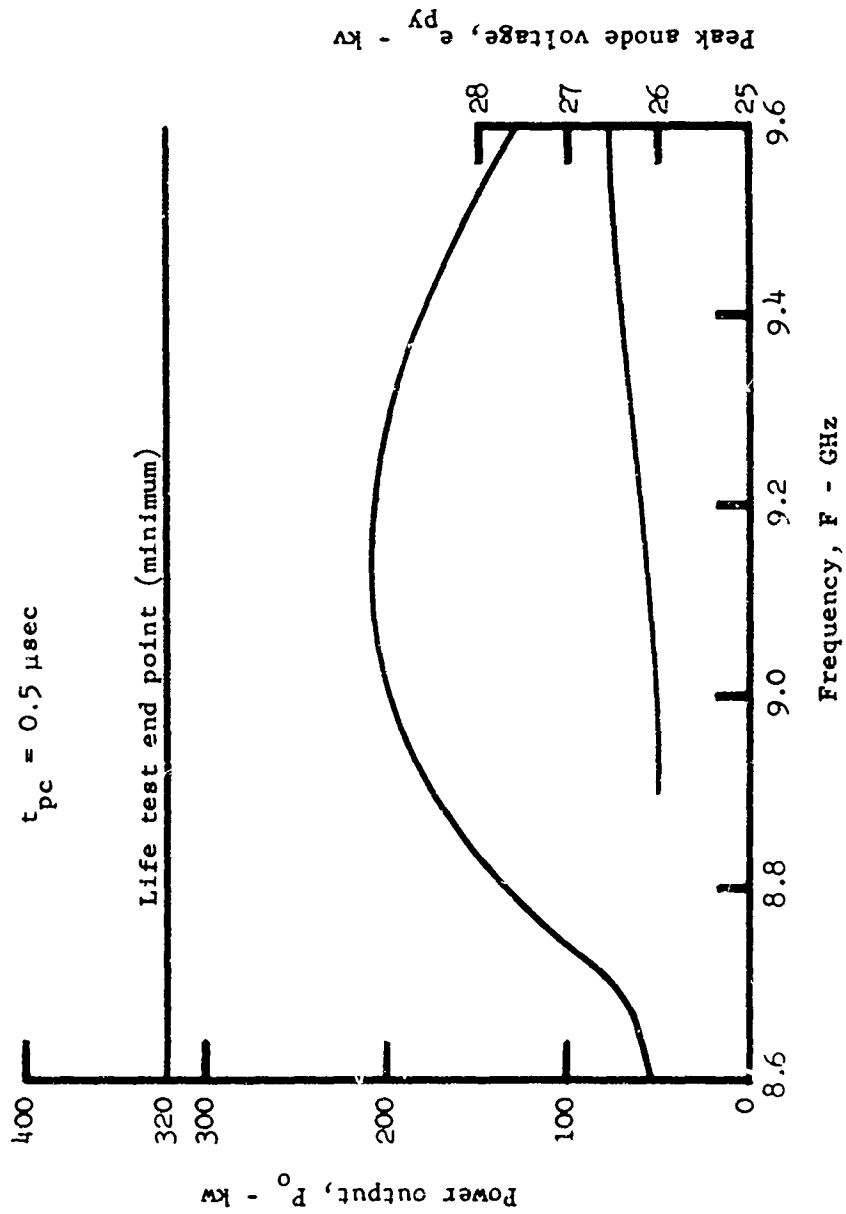


FIGURE 2 POWER OUTPUT AND VOLTAGE CHARACTERISTICS AT END OF LIFE TEST

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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 μ sec pulse length failed, and the tube was finally operated at a pulse length of 0.5 μ sec. 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.

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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13. ABSTRACT ✱ The manufacturing methods program under which this tube was developed required that the final report be delivered prior to completion of the life test. The SFD-328 accumulated over 5000 hours of life test time prior to failure, which terminated the test. — This report presents the results of the life test program, and indicates possible reasons for the failure of the life test vehicle.		

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