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NAFEC TECHNICAL LETTER REPORT

78-64

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AN EVALUATION OF THE VIDEO PRODUCTS 23-INCH CATHODE RAY TUBE

by

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ABSTRACT

Video Products Company of Van Nuys, California, was awarded a contract to deliver 1,025 23-inch Cathode Ray Tubes (CRTs) to the Federal Aviation Administration (FAA) to be used in the Plan View Display (PVD). This was the first contract for the 23-inch CRT that had not been awarded to the Raytheon Company. It was necessary to establish that the tests performed by Video Products are equivalent to those previously approved for Raytheon.

An equivalent method for doing brightness and linewidth measurements was found using Video Products test equipment.

A follow-up investigation of CRTs being received by the field from Video Products indicates that there are some problems--the major ones being arcing and poor focusing. Solutions to these problems are being investigated.

PURPOSE

The purpose of this report is to present the results of an evaluation of the proposed procedures to be used by Video Products in their quality assurance tests on the 23-inch CRT. This CRT is used in the Air Route Traffic Control Center (ARTCC) display (Type FA-7912). It also presents a follow-up evaluation of the CRTs being received from Video Products.

BACKGROUND

Video Products is the first CRT manufacturer, other than Raytheon, to produce a large quantity of the 23-inch CRTs used in the Plan View Display (PVD). Video Products does not have the test equipment necessary to perform light measurements in the exact way described in the original production tests. However, they do have function generators that will produce a variable size raster and a light meter (Spectra FC-200A) with a sensing area of approximately 2 inches in diameter, to measure raster brightness.

It was hoped that a correlation could be found between this method of measurement and the single line method specified in the original production tests.

DISCUSSION

Video Products has a quality assurance test station that employs a raster produced by two function generators. The vertical deflection signal is a 60-hertz (Hz) linear sweep and the horizontal signal is approximately a 16.5-kilohertz (kHz) triangular waveform. Both of these signals are adjustable. This type of setup produces a raster that is composed of horizontal lines which "zig-zag" back and forth across the screen, meeting at the left and right edges of the screen as shown in figure 1.

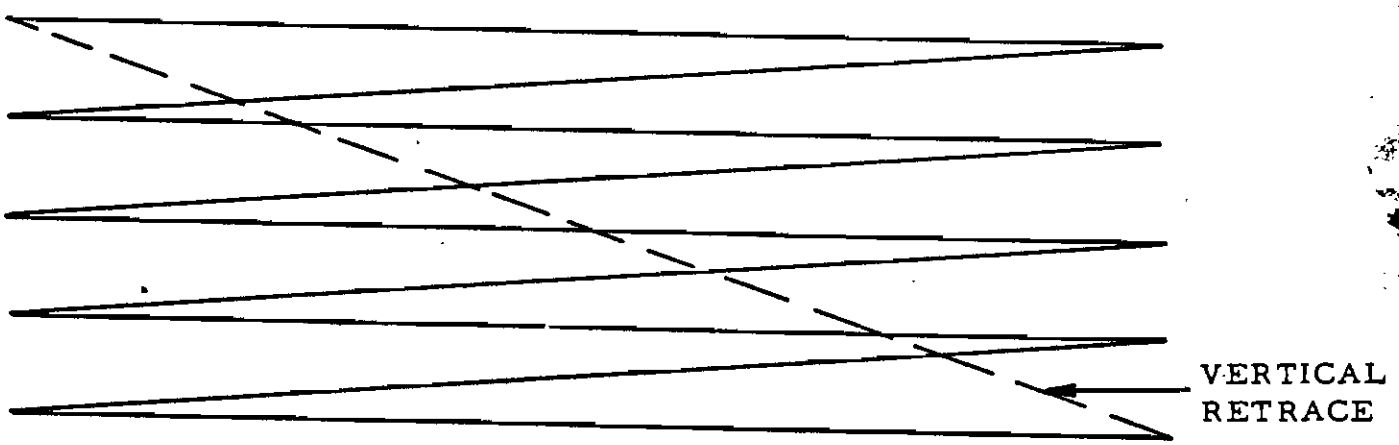

FIGURE 1. SIMPLIFIED EXAMPLE OF A HORIZONTAL AND VERTICAL DEFLECTION SIGNAL

In figure 1, nine "active" horizontal lines are shown--the actual raster had roughly 450 active lines, with another 150 lines written over each other at the bottom of the raster because of vertical sweep dead time.

The period of the triangular waveform ($\frac{1}{16.5\text{kHz}}$) was approximately 60 microseconds (μ sec) and, therefore, the time to write one horizontal line was about 30 μ sec. The writing rate of these lines could, therefore, be adjusted by changing the horizontal width of the raster. The raster was adjusted to 9 inches horizontally to produce a writing rate of 0.3 inches per sec. To produce a writing rate of 0.5 inches per sec, the raster was adjusted to a width of 15 inches. The refresh rate was equal to the vertical sweep rate (60 Hz).

Single-line light measurements were performed after spreading the raster out vertically to a point where the space between horizontal lines was one-quarter inch as measured from the middle of the lines. This light measurement technique, as specified in Mitre Report #669, and in the original production test, uses Gamma Scientific microscope (Model #700-10-1) with a 45 x 45 mil (1 mil = .001 inch) aperture. It is the method generally used in evaluating these 23-inch CRTs. The specification calls for a brightness of 63 footlamberts (fL) at a writing rate of 0.5 inches per μsec and a refresh rate of 55 Hz. Since we were using a refresh rate of 60 Hz, we set up the brightness to 63 times 60/55 or 68.7 fL, plus 1.3 fL to account for the background light caused by the rest of the raster. Therefore, the brightness was actually set for 70 fL.

We then tried to measure the linewidth using the scanning-micrometer eye-piece (Gamma #700-10-66) attached to the microscope. There was too much jitter, however, on the raster lines to get usable data. We then used the Edmund Scientific hand-held microscope (Model No. 70,266), to measure the "trace-width." This "trace-width" is the width of the line that the human eye sees, which is discerned to a brightness of 10 percent of the peak brightness. (See figure 2.)

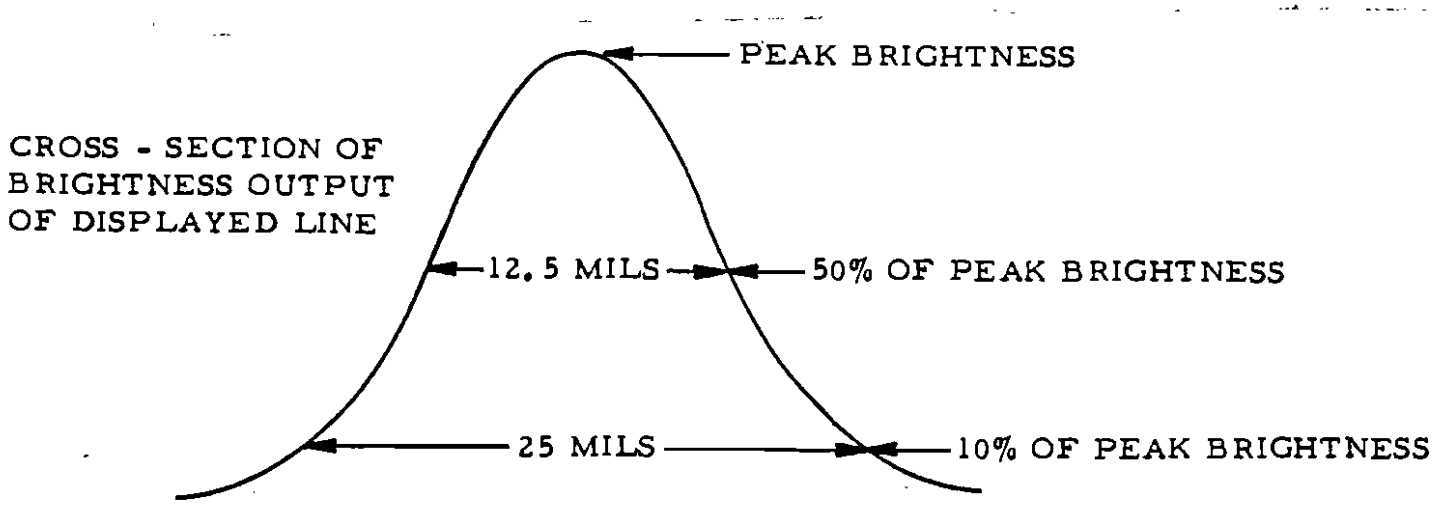

FIGURE 2. TRACE-WIDTH MEASURE

Several people took the measurement on the same line, including personnel from Video Products, ALG-430 and ANA-140. Everyone read approximately 25 mils. Measurements performed at NAFEC have indicated that this "trace-width" is approximately twice the linewidth measured using the 50-percent brightness points and the single-line Mitre technique.

It was also necessary to develop a raster light measurement technique using the Video Products equipment, that would compare to the single-line method using the Gamma equipment. After much discussion and testing, the following test was performed.

The raster was expanded vertically until the horizontal raster lines were approximately 1/4-inch apart. The brightness was then set at 70 fL using the Gamma microscope to take the brightness measurement on a single line of the raster. Next, the raster was shrunk down to a vertical distance equal to the "trace-width" multiplied by the total number of active lines. Video Products' brightness meter was then used to take a brightness measurement. This meter read 65 fL, which was very close to what was measured on the single line using the Mitre technique.

This test has been performed on several different CRTs at NAFEC using a Weston No. 759 footlambert meter (similar to the Spectra meter) with correlative results.

Most of the CRTs tested met the brightness and linewidth conditions of the specification as modified for the Video Products test equipment. However, the cathode current was too high—in the order of 200 microamps (μ A). It was proposed that the measurement be performed at 70 fL with a 9-inch-wide horizontal raster. This produced a writing rate of 0.3 inches per μsec, which is the fastest writing rate of the PVD in the CDC mode and is believed to be the writing rate used by Raytheon. At this slower writing rate, the cathode current was only 50 μA at 70 fL and the "trace-width" was now about 22 mils.

It was, therefore, tentatively decided that Video Products could use a 9-inch-wide by 10-inch-high raster set at a brightness of 70 fL using the Spectra brightness meter. A "trace-width" of 22 mils multiplied by a total number of active lines of 450 calculated to a raster height of approximately 10 inches. To then perform a linewidth measurement, this raster was expanded vertically until the individual raster lines were approximately 1/4 inch apart. Now a "trace-width" measurement could be performed using the hand-held microscope, with the linewidth (50-percent peak brightness) being approximately half of that measurement.

In order to check the accuracy of this proposed measurement technique, three tubes were shipped to NAFEC for further testing. The test data sheets for these tubes are shown in appendix A.

The first Video Products CRT received at NAFEC, Serial Number 31, had a problem with small "smudges" of CDC-type data. These "smudges" were mostly concentrated in a circular region of approximately 6 inches in diameter, concentric to the

center of the screen. The second CRT, Serial Number 39, arced several times when it was first biased on and continued to arc intermittently for a few minutes, until we decided to "spot-knock" the tube. "Spot-knocking" is a process in which all the elements in the gun of the CRT are tied to ground, and approximately 20,000 volts is intermittently applied to the anode. This process will, in many cases, clear arcing in a CRT, allowing normal use of the tube. However, in some cases, a tube that has been cleared of arcing by this method will start arcing again after some period of normal use. After the second CRT was spot-knocked, it arced less frequently, but we were unable to stop the arcing entirely.

Video Products was made aware of the problems with CRTs, Serial Numbers 31 and 39, in order to rectify these problems in the future.

The last CRT received from Video Products was completely acceptable. As can be seen from the data sheet, the center-screen linewidth was close to 13 mils, but if we consider a test equipment accuracy of ± 1 mil, the linewidths were within test limits.

Serial Number 31 was placed on life-test in order to see how it would compare to a Raytheon tube being run under the same conditions. Number 31 was used for this test because, other than for the problem on the phosphor (smudging), this was a normal tube. We did not want to waste Serial Number 40 in what is really a destructive type test. So far, the tube has been run for 1,700 hours at a beam current of 200μA and 1,000 hours at a beam current of 300μA. These were the same conditions used for the Raytheon CRT. After 2,700 hours of these accelerated life-tests, there has not been any appreciable change in the condition of the CRT.

Since the start of the delivery of these CRTs to the field, there have been some complaints received about their performance. The major grievances have been problems with arcing and poor focusing.

It was discovered that Video Products was installing the tension-band and mounting ears after they did the production tests. As part of this installation procedure, it was sometimes necessary to hit the tension-band or the mounting ears with a mallet to position them correctly. This may have caused particles to be loosened inside the tube. These particles could then fall into the gun and possibly cause arcing. Video Products has now been instructed to perform all electrical tests after the CRT is completely assembled. As part of the contract, Video Products is supplying a high-voltage regulator vacuum tube with each CRT. This regulator is used in the dynamic focus module, which it biases to the proper output voltage range for that particular CRT. This regulator should have an operating voltage of 200 to 400 volts less than the center screen focus voltage of the CRT under normal operating conditions. Reports from the field indicate that a 2500-volt regulator tube is almost always shipped with a Video Products' CRT. This would mean that the center-screen focus voltage on these tubes is almost always between 2,700 and 2,900 volts. The allowable range for the center-screen focus voltage is 2,600

to 3,000 volts. It seems unlikely that almost all of the Video Products' CRTs have a focus voltage that falls inside the smaller 200-volt range. However, the three CRTs shipped to NAFEC did fall within this range.

CONCLUSIONS

1. A technique for taking brightness and linewidth measurements was found using Video Products test equipment that correlated with the previously used methods and equipment.

2. The field has reported difficulties with the Video Products 23-inch CRT--the major ones being arcing and poor focusing.

RECOMMENDATIONS

1. Video Products should perform their electro-optical tests after final assembly of the CRT.

2. Video Products should make sure they are sending the proper high-voltage regulator tube with each CRT.

3. The field should make sure the proper high-voltage regulator tube is installed with each new CRT.

4. The Air Route Traffic Control Centers (ARTCC) should purchase a "Spot-Knocker" so that they can clear (in many cases) the arcing they have been having in both Video Products and Raytheon CRTs.

5. The ARTCCs should also check the G-2 voltage at the gun connector and the high voltage at the anode button of the Plan View Display (PVD) with a very high impedance voltmeter. This meter should have an input impedance of at least 1,000 megohms. There are high-voltage probes available on the market that act as 1,000-to-1 voltage dividers on the input to digital voltmeters. The digital voltmeter is required to have an input impedance of 10 megohms, which is somewhat of a standard. These high-voltage probes have an input impedance of 10,000 meg-ohms.

The work effort described in this letter report was accomplished by the ATC Applications Branch under NPD SE-190 Display Applications Engineering, Subprogram Number 124-111 Enroute Sustaining Engineering. The NAFEC Program Manager is Phil Gustafson. The associated 9550 is number AAC-ARD-078-X06 entitled "Correlation of 23-Inch PVD CRT Measurement." For further information concerning this project, contact Mr. John Aschenbach, ANA-270 (609) 641-8200, extension 3087.

APPENDIX A

TEST DATA SHEETS

TUBE # VIDEO Products #31 DATE : 3/31/78

ELECTRO - OPTIC DATA

Additional Notes -

Cut Off 74 size 23"

* position on tube;
VLC- verticle line center
HLL- horizontal line center

BRIGHTNESS FT. LAMBERT	GRID DRIVE VOLTS	FOCUS VOLTAGE VOLTS	LINE WIDTH MILS	* POSITION ON TUBE	ANODE VOLTAGE KILOVOLTS	WRITING SPEED INCH/MICRO SEC
68.7	31.5	2850	11.9	VLC	18KV	.3"/μs
	BEAM	2850	11.0	HLC		
	CURRENT	3250	12.6	HLL		
	≈ 70μA	3050	16.8	VLL		
		3050	15.8	VLR		
		* 3050	12.8	HLR		
		3050	12.5	HLT		
		3250	9.0	VLT		
		3250	9.3	VLB		
		3050	13.7	HLB		
68.7	44.7	2825	13.9	VLC	18KV	.5"/μs
		2825	13.1	HLC		.5"/μs

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DATA SHEET

Serial No: VIDEO #31
Date: 3/31/78

PARAMETER	E_{c1}	E_{c2}	E_{b1}	E_{b2}	I_K	E_f	I_f	E_{HK}	to E_{c1}		LIMITS		TEST		NOTES
UNITS	V	V	KV	KV	uA	V	mA	V			MIN.	MAX.	RESULTS		
ELECTRICAL RATINGS															
PIN #2 GRID #1 E_{c1} (V)	ADJ.										-170	0			
PIN #10 GRID #2 E_{c2} (V)		600									500	850			
A HV ANODE E_{b1} (KV)			18								10	20			
PIN #6 Focus Anode E_{b2} (KV)				2.8							2	4			
BEAM CURRENT I_{b1} (μA)					—						0	300			
PIN #1,12 Fil. Volts E_f (V)						6.3					5.67	6.93			
Fil. Current I_f (mA)							600				540	660			
PIN #11 Cathode E_{HK} (V)								—			-200	+200			
TEST CONDITIONS, LIMITS & RESULTS															
Focus Voltage - E_{b2} (KV)											2.6	3.0	2.8		CENTER SCREEN FOCUS
Cut-Off Voltage - Spot (V)											-35	-85	-74		(MAXIMUM CENTER-TO-EDGE
" " VOLTAGE FULL RASTER (V)											-35	-85	-69		FOCUS VOLTAGE +50 VOLTS
Voltage Breakdown (ARCS)											0	2			
Heater To Cathode E_{HK}^+ (μA) LEAKAGE											0	10	0		
" " " " E_{HK}^-											0	10	1.5		
Grid #1 (G1) LEAKAGE (μA)											0	3	1.		
Grid #2 (G2) LEAKAGE (μA)											0	5	0		
Anode Leakage (μA)											0	5	0		
STRAY Emission											none		Dim spot 1/8" off center		
Heater Current (mA)											540	660	620		
UNDEFLECTED SPOT POSITION (INCHES)											0	.25	1/8		
GAS RATIO (μA)											0	.06	.016		
Focus Anode Current (μA)											0	20	1		
MODULATION (V) 300μA											20	50	52		
" " 100μA											15	35	35		
Screen Quality															There are some smudges on the phosphor surface

TUBE # VIDEO #39 DATE : 4/3/78

ELECTRO - OPTIC DATA

Additional Notes -

Cut Off 76 size 23"

* position on tube;
VLC- verticle line center
HLL- horizontal line center

BRIGHTNESS FT. LAMBERT	GRID DRIVE VOLTS	FOCUS VOLTAGE VOLTS	LINE WIDTH MILS	* POSITION ON TUBE	ANODE VOLTAGE KILOVOLTS	WRITING SPEED INCH/MICRO SEC
68.7	35.3	2700	11.5	VLC	18KV	.3"/μs
		2700	11.5	HLC		
		3075	13.3	HLL		
		2850	15.1	VLL		
		2850	13.0	VLR		
		3075	9.3	HLR		
		2850	13.5	HLT		
		3075	9.3	VLT		
		3075	10.8	VLB		
73.5		2850	14.3	HLB		
68.7	43.3	2625	11.9	VLC	18KV	.5"/μs
		2625	12.4	HLC		

DATA SHEET

Serial No: VIDEO #39
Date: 4-3-78

PARAMETER	E_{c1}	E_{c2}	E_{b1}	E_{b2}	I_K	E_f	I_f	E_{HK}	E_{c1}		LIMITS		TEST		NOTES
UNITS	V	V	KV	KV	μA	V	mA	V			MIN.	MAX.	RESULTS		
ELECTRICAL RATINGS															
PIN #2 GRID #1 E_{c1} (V)	ADJ.										-170	0			
PIN #10 GRID #2 E_{c2} (V)		600									500	850			
A1 HV ANODE E_{b1} (KV)			18								10	20			
PIN #6 Focus Anode E_{b2} (KV)				2.8							2	4			
BEAM CURRENT I_{b1} (μA)					—						0	300			
PIN #1,12 Fil. Volts E_f (V)						6.3					5.67	6.93			
Fil. Current I_f (mA)							600				540	660			
PIN #11 Cathode E_{HK} (V)								—			-200	+200			
TEST CONDITIONS, LIMITS & RESULTS															
Focus Voltage - E_{b2} (KV)											2.6	3.0	2.7		CENTER SCREEN FOCUS
Cut-Off Voltage - Spot (V)										-73	-35	-85	-75		(MAXIMUM CENTER-TO-EDGE
" " VOLTAGE FULL RASTER (V)											-35	-85	-69		(FOCUS VOLTAGE 450 VOLTS
Voltage Breakdown (ARCS)											0	2	YES		ARCED REPEATEDLY, WAS — Spot knocked - emission
Heater To Cathode E_{HK}^+ (μA) LEAKAGE											0	10	1		dropped - rejuv by HOT SHOT
" " " " E_{HK}^-											0	10	.7		and 500μA current,
Grid #1 (G1) LEAKAGE (μA)											0	3	.1		AFTER THIS, IT STILL
Grid #2 (G2) LEAKAGE (μA)											0	5	0		ARCED ONCE IN A WHILE
Anode LEAKAGE (μA)											0	5	0		
STRAY EMISSION											none		—		
Heater Current (mA)											540	660	615		
UNDEFLECTED SPOT POSITION (INCHES)											0	.25	1/8		
GAS RATIO (μA)											0	.06	.0028		
FOCUS ANODE CURRENT (μA)											0	20	-1		
MODULATION (V) 300μA										39	20	50	70		
" " 100μA										33	15	35	41/52		
Screen Quality															

TUBE # VIDEO #40 DATE : 4/6/78

ELECTRO - OPTIC DATA

Additional Notes -

Cut Off-64

size 23"

* position on tube;
VLC- vertic'e line center
HLL- horizontal line center

BRIGHTNESS FT. LAMBERT	GRID DRIVE VOLTS	FOCUS VOLTAGE VOLTS	LINE WIDTH MILS	* POSITION ON TUBE	ANODE VOLTAGE KILOVOLTS	WRITING SPEED INCH/MICRO SEC
68.7	31.5	2850	12.9	VLC	18KV	.3"/μS
		2850	12.8	HLC		
		3250	16.8	HLL		
		3075	20.8	VLL		
		3075	17.4	VLR		
		3250	12.4	HLR		
		3075	16.8	HLT		
		3250	10.9	VLT		
		3250	9.0	VLB		
		3075	12.7	HLB		
68.7	40	2825	12.7	VLC	18KV	.5"/μS
		2825	12.9	HLC		

DATA SHEET

TUBE TYPE: 23"
Serial No: VIDEO #40
Date: 4/4/78

PARAMETER	E_{c1}	E_{c2}	E_{b1}	E_{b2}	I_K	E_f	I_f	E_{HK}	$10E_{c1}$		LIMITS MIN.	LIMITS MAX.	TEST RESULTS		NOTES
UNITS	V	V	KV	KV	uA	V	mA	V							
ELECTRICAL RATINGS															
PIN #2 GRID #1 E_{c1} (V)	ADJ.										-170	0			
PIN #10 GRID #2 E_{c2} (V)		600									500	850			
A1 HV ANODE E_{b1} (KV)			18								10	20			
PIN #6 Focus Anode E_{b2} (KV)				2.8							2	4			
BEAM CURRENT I_{b1} (μA)					—						0	300			
PIN #1,12 Fil. Volts E_f (V)						6.3					5.67	6.93			
Fil. Current I_f (mA)							600				540	660			
PIN #11 Cathode E_{HK} (V)								—			-200	+200			
TEST CONDITIONS, LIMITS + RESULTS															
Focus Voltage $-E_{b2}$ (KV)											2.6	3.0	2.86		CENTER-SCREEN FOCUS
Cut-Off Voltage - Spot (V)											-35	-85	-64		(MAXIMUM CENTER-TO-EDGE
" " VOLTAGE FULL RASTER (V)											-35	-85	-58		FOCUS VOLTAGE 450 VOLTS)
Voltage Breakdown (ARCS)											0	2	0		
Heater To Cathode E_{HK}^+ LEAKAGE (μA)											0	10	1		
" " " " $E_{H^+K^-}$											0	10	1		
Grid #1 (G1) LEAKAGE (μA)											0	3	.2		
Grid #2 (G2) LEAKAGE (μA)											0	5	0		
Anode LEAKAGE (μA)											0	5	<5		
STRAY EMISSION											none				
Heater Current (mA)											540	660	600		
UNDEFLECTED SPOT POSITION (INCHES)											0	.25	1/8		
GAS RATIO (μA)											0	.06	.064		
FOCUS ANODE Current (μA)											0	20	0		
MODULATION (V) 300μA											20	50	44		
" " 100μA											15	35	31		

APPENDIX B
NA-78-64-LR

Distribution:
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