PERFORMANCE SPECIFICATION SHEET

ELECTRON TUBE, GAS SWITCHING

TYPE DOD-004 *

This specification is approved for use by all Departments and Agencies of the Department of Defense.

The requirements for acquiring the electron tube described herein shall consist of this document and the latest issue of MIL-PRF-1.

DESCRIPTION: Dual TR with external shutters, 15,800 to 17,000 MHz, 60 kw.

ABSOLUTE RATINGS:

Parameter:	Esol	Ii	Ignitor voltage	Transmitter po	TA	Alt
Unit:	V dc	µA dc	V dc	kw	°C	ft
Maximum:	29	200	---	60	+125	60,000
Minimum:	21	100 1/	-850	---	-55	---

PHYSICAL CHARACTERISTICS:

Dimensions: See figures 5 and 6.

Weight: 6.0 ounces.

Mounting: 2/

TEST CONDITIONS:

Parameter:	Ignitor voltage	Transmitter po	tp	prr	F
Unit:	V dc	kw	µs	pps	MHz
Test condition 1:					
Maximum:	870	---	---	---	---
	---	---	---	---	F1
Minimum:	850	---	---	---	---
Test condition 2:					
Maximum:	870	---	0.50	---	---
	---	0.060	---	2,400	F1
Minimum:	850	---	0.30	---	---
Test condition 3:					
Maximum:	870	---	1.10	---	---
	---	60	---	2,400	F3
Minimum:	850	---	0.90	---	---

Frequency		
F	MHz	±
F1	15,800	16
F2	16,000	16
F3	16,200	16
F4	16,500	16
F5	17,000	16

GENERAL:

Qualification: Required.

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* Formerly BTR-141

TABLE I. Testing and inspections.

Requirement or test	Method	Notes	Test	Conditions	Symbol	Limits		Unit
						Min	Max	
Qualification inspection								
Barometric pressure, reduced	1002	---	1	54.24 torr	---	---	---	---
Low-level inter-channel isolation	---	3/	---	F = F2, F4, and F5; po = 10 mw (max)	Li	50	---	dB
Phase shift	---	4/ 5/ 6/ 7/	1	F = F2 and F5; TA = +125°C to -55°C	ΔØ	---	1.5	Degrees
Phase recovery	---	8/ 9/	2	F = F2 and F5; po = 4 ± 0.4 kw; TA = +125°C to -55°C	ΔØ	---	0.2	Degree
Degradation due to vibration	4021	10/	---	F = 5 Hz to 500 Hz; Eso1 = 21 V dc; t = 15 minutes	---	---	---	---
Shutter phase modulation	---	11/	---	F = F4; Eso1 = 21 ± 0.5 V dc; TA = +25°C to -25°C t = 10 minutes (min)	ΔØ	---	0.1	Degree
Shutter holding current	---	12/	---		---	---	235	mA dc
Temperature cycling	1027	---	---	10 cycles (min)	---	---	---	---
Conformance inspection, part 1		13/						
Ignitor ignition time	4401	1/ 14/	1		t	---	5.0	sec
Ignitor current	---	1/ 14/	1		Ii	130	165	µA dc
Ignitor interaction (insertion loss)	4421	1/ 14/	1		ΔLi	---	0.1	dB
Ignitor current noise	---	15/	---		---	---	---	---
Insertion loss	4416	14/ 16/	1	F = F1, F4, and F5	Li	---	0.6	dB
Insertion loss	4416	14/ 16/	1	F = F1, F4, and F5 (shutter closed)	Li	25	---	dB
Static phase unbalance	---	7/	---	F = F1 through F5	---	ΔØ	1.5	Degrees
Low-level VSWR	4473	14/ 16/	1	F = F1 through F5	σ	---	1.4	---
Leakage power (flat)	4452	17/ 18/	2 2		pf pf	--- ---	100 20	mw mw

See footnotes at end of table.

TABLE I. Testing and inspections - Continued.

Requirement or test	Method	Notes	Test	Conditions	Symbol	Limits		Unit
						Min	Max	
Conformance inspection, part 1 - Continued		13/						
Leakage energy (spike)	4452	17/	2		Ws	---	0.5	erg
		18/	2		Ws	---	0.1	erg
Recovery time	4471	8/	3		t	---	1.0	µs
Firing power	4496	14/	1		Po/Du	30	200	mw
Phase shift	---	5/ 6/ 14/	1	See figure 7				
				F = F1	ΔØ	44.5	47.5	Degrees
				F = F4	ΔØ	346.0	349.0	Degrees
				F = F5	ΔØ	309.5	312.5	Degrees
Shutter current	---	19/	---	Eso1 = 28 ± 0.5 V dc	Iso1	---	435	mA dc
Shutter cycling	---	20/	---	Eso1 = 28 ± 1 V dc; prr = 10 Hz (max); 250 cycles	---	---	---	---
Conformance inspection, part 2								
Ignitor current	---	1/ 14/	1	TA = +125°C and -55°C	Ii	130	190	µA dc
Ignitor noise ratio	4460	---	1		Nr	---	1.3	---
Noise figure change	---	---	1		ΔNF	---	1.2	dB
Leakage power (flat)	4452	17/	2	TA = +125°C	pf	---	100	mw
Leakage energy (spike)	4452	17/	2	TA = +125°C	Ws	---	0.5	erg
Firing power	4496	14/	1	TA = +125°C	Po/Du	30	200	mw
Recovery time	4471	8/	3	TA = -55°C	t	---	1.0	µs
Arc loss	4488	---	2	po = 20 ± 1 kw	Loss	---	0.8	dB
Shutter current	---	19/	---	Eso1 = 28 ± 0.5 V dc; TA = +125°C and -55°C	Iso1	---	435	mA dc
Shutter cycling	---	20/	---	Eso1 = 28 ± 1 V dc; prr = 10 Hz (max); TA = +25°C 1,000 cycles	---	---	---	---
Phase recovery	---	8/ 9/	1	po = 4 kw; TA = -55°C	ΔØ	---	0.2	Degree

See footnotes at end of table.

TABLE I. Testing and inspections - Continued.

Requirement or test	Method	Notes	Test	Conditions	Symbol	Limits		Unit
						Min	Max	
Conformance inspection, part 3								
Life test	---	21/ 22/	2	Group D; F = F3; po = 100 ± 10 kw; TA = +125°C	t	1,000	---	hrs
Life test end points:	---							
Recovery time	4471	8/	3		t	---	2.0	µs
Crystal degradation	---	21/	---		ΔNF	---	1.0	dB
Insertion loss	4416	1/ 14/	1		Li	---	0.6	dB
Ignitor noise ratio (noise figure change)	4460	---	1		NF	---	1.2	dB
Phase shift	---	5/ 6/ 7/ 14/	1	See figure 7				
				F = F1	ΔØ	44.5	47.5	Degrees
				F = F4	ΔØ	346.0	349.0	Degrees
				F = F5	ΔØ	309.5	312.5	Degrees
Firing power	4496	14/	1		Po/Du	30	200	mw
Leakage energy	4452	17/	2		Ws	---	0.5	erg
(spike)		18/	2		Ws	---	0.1	erg
Shutter cycling life test	--	20/	---	Eso1 = 29 ± 1 V dc; prr = 10 Hz (max); TA = +125°C	---	50,000	---	Cycles
Shutter cycling life-test end points:	---							
Insertion loss	4416	14/ 16/	1	F = F1 through F5	Li	---	0.6	dB
Insertion loss	4416	14/ 16/	1	F = F1, F4, and F5 (shutter closed)	Li	25	---	dB
Degradation due to vibration	4021	10/	---	F = 5 Hz to 500 Hz; Eso1 = 21 V dc; t = 15 minutes	---	---	---	---
Shutter phase modulation	---	11/	---	F = F4; Es = 21 ± 0.5 V dc; TA = +25°C and -25°C; t = 10 minutes (min)	ΔØ	---	0.1	Degree

1/ Two resistors, one in series with each ignitor, are encapsulated as integral parts of the tube. They are selected to provide a current of 150 µA dc nominal when the specified voltage, Ebb = -860 V dc, is applied to the ignitor terminals (No. 1 and No. 2) of the tube.

2/ A suitable gasket should be bolted between each flange of the tube and its mating flange (see figure 6).

3/ The minimum interchannel isolation (crosstalk) requirements shall be met when the tube is mounted between waveguide adapters with standard 0.040 commonwall flanges. Tube shall be in the deionized state for this test.

4/ The shutters provide a convenient method of opening or shorting a waveguide line at low-power levels (incident peak power less than 1 kw). They are not intended for applications involving the switching of high power, and should remain open or closed whenever high power is incident on the tube.

TABLE I. Testing and inspections - Continued.

5/ The phase length of the tube shall be measured relative to an equivalent length of RG-91/U waveguide. The phase slope deviation shall not exceed ±1.5 degrees (max) at any operating frequency.

6/ When using a phase shifter (rotary vane type such as a Hewlett-Packard No. P885A, or equivalent) record the phase shifter dial reading using only the top scale and vernier, when the circuit has been balanced.

7/ The static phase unbalance between the two channels of the tube shall be less than the specified value and shall not deviate from the equivalent line length with frequency by more than 1.5 degrees.

8/ The recovery time shall be measured at the point where the signal level has recovered to within 0.5 dB of the full-signal level.

9/ With the static phase error balanced, the dynamic phase unbalanced between the two channels shall be less than the specified value of 1.0 microseconds. Recovery time shall be compatible with dynamic phase.

10/ The shutter shall be held open during vibration by the specified minimum voltage. Vibrate in a plane parallel to the axes of the shutters. The insertion loss test set up shall be used with the unit under test mounted on the vibrator such that a standard waveguide section of similar geometry may be substituted for the shutter tube. The modulation (ΔLi) due to vibration shall not be greater with the shutter tube in the line than with the waveguide section.

11/ Shutter phase modulation.

a. Introduction. The measurement of rf phase modulation introduced during vibration of the shutter mechanisms in crystal protector tubes can be performed by either of the two indirect techniques to be described. Direct measurement of this parameter is not practical because the phase modulation introduced by the waveguide test equipment will generally be far greater than the permissible shutter modulation.

b. Description of shutter mechanism.

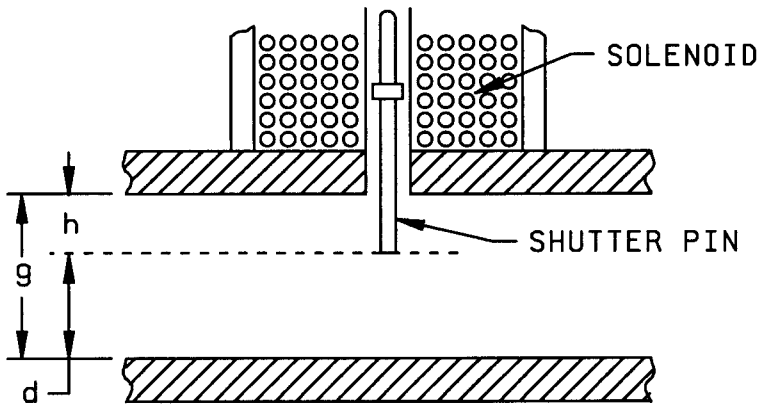


FIGURE 1. Sketch of shutter mechanism.

The shutter pin is attached to a magnetic armature which is located in the magnetic field set up by a solenoid. In the absence of solenoid voltage, the shutter pin is forced against the opposing wall by the force of a shutter closing spring. The rf gap "g" is shorted in this condition and reflects incident signals. With the application of solenoid voltage, the shutter pin is withdrawn from the rf gap against the force of the spring and comes to rest at a height "h" above the opposing wall. Under this condition, the shutter mechanism introduces no appreciable loss to rf signals passing through the crystal protector tube.

TABLE I. Testing and inspections - Continued.

c. Phase calibration.

(1) A shutter mechanism consisting of the shutter pin and the two opposing walls is assembled into a flanged section of waveguide. A calibrated micrometer drive is attached to the shutter pin and permits manual drive of the pin from the shorted condition (i.e., shutter pin resting against the opposing wall) to the "open" condition (i.e., shutter pin at a distance "d" from the opposing wall).

(2) The waveguide section containing the micrometer driven shutter assembly is inserted into an rf phase bridge as shown on figure 2.

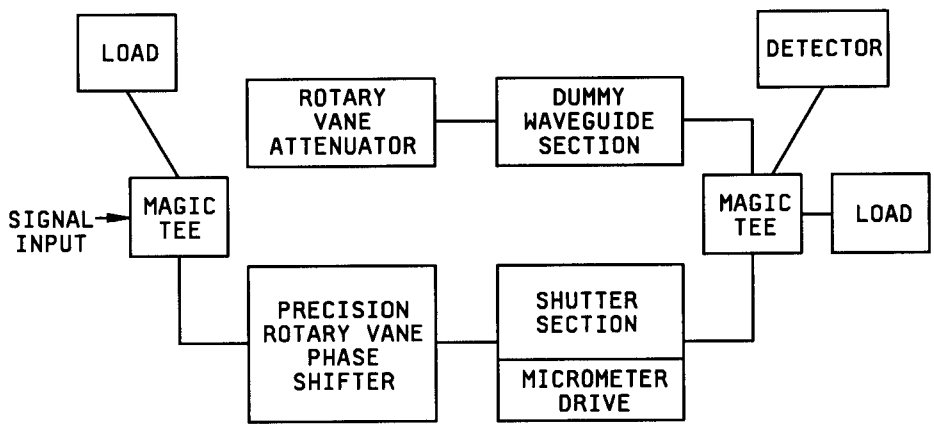


FIGURE 2. Shutter phase calibration.

(3) Using the micrometer drive, the shutter pin is driven against the opposing wall and the phase bridge is balanced with the phase shifter. A balanced condition, as indicated by a null at the detector output, will require insertion of attenuation in the attenuator leg to compensate for the isolation of the shutter. An exact balance is not required at this point. The micrometer reading for this shorted condition of the shutter is recorded.

(4) The shutter pin is then retracted from the shorted condition in small increments and the phase bridge rebalanced at each micrometer setting. Both the attenuator and the phase shifter shall be reset at each balancing in order to obtain the maximum depth of null at the detector. It will be noted that the amount of phase shifter change required per increment of micrometer movement will diminish as the shutter pin moves out of the gap "g".

(5) Further retraction of the shutter pin outside the gap region will lead to a critical separation "d", beyond which the motion of the shutter pin no longer has any effect on the phase characteristic of the assembly. This condition will be evidenced by the fact that the bridge will remain in balance (null at the detector) without requiring further adjustment of the phase shifter. The micrometer reading at the critical separation "d" is then subtracted from the initial reading at the shorted condition to establish the value of "h".

d. Vibration testing. Vibration testing shall be carried out over the frequency range extending from 10 to 500 Hz to 10 Hz at a 0.06-inch double amplitude displacement (to a maximum of 10 G) in accordance with MIL-STD-202, method 204, test condition A. In order to avoid phase modulation, the shutter pin separation from the opposing wall shall always be greater than the critical spacing "d" for all conditions of vibration. Either optical or electrical means may be used to demonstrate that the shutter design has satisfied this requirement. The voltage applied to the shutter solenoid shall be the minimum allowable under the applicable specification (21 V dc). The shutter shall be vibration tested at the minimum shutter holding power level determined under quiescent conditions at Es = 21 V dc and TA = +125°C.

TABLE I. Testing and inspections - Continued.

e. Optical measurement technique. The wall surrounding the shutter pin is cut back or removed entirely in order to expose the shutter pin for optical observation. The shutter mechanism is then mounted on a suitable vibration table and the shutter pin is observed through a rigidly mounted telescope. The shutter is illuminated by a strobe light which is synchronized to the motion of the vibration table. The telescope is aimed so that a reference marker (e.g., crosshairs) is pointed at the critical distance "d" from the wall opposing the shutter pin. The shutter pin is then withdrawn from the opposing wall by application of the reduced shutter voltage and the assembly is vibrated over the applicable range. Any travel of the shutter pin from its fully withdrawn position (distance "d" from the opposing wall) is observed through the telescope. The extent of this travel shall not reach beyond the critical spacing "d".

f. Electrical measurement technique. For this technique, the opposing wall is drilled out similarly to the wall containing the shutter pin. An insulated electrical contact is then passed through this wall and adjusted until its tip is at the distance "d" above the end of the shutter opposing wall. The wall surrounding the shutter pin is cut back or removed as for the optical technique. The electrical connections are then made as shown on figure 3. The shutter pin is maintained at case potential through the shutter closing spring.

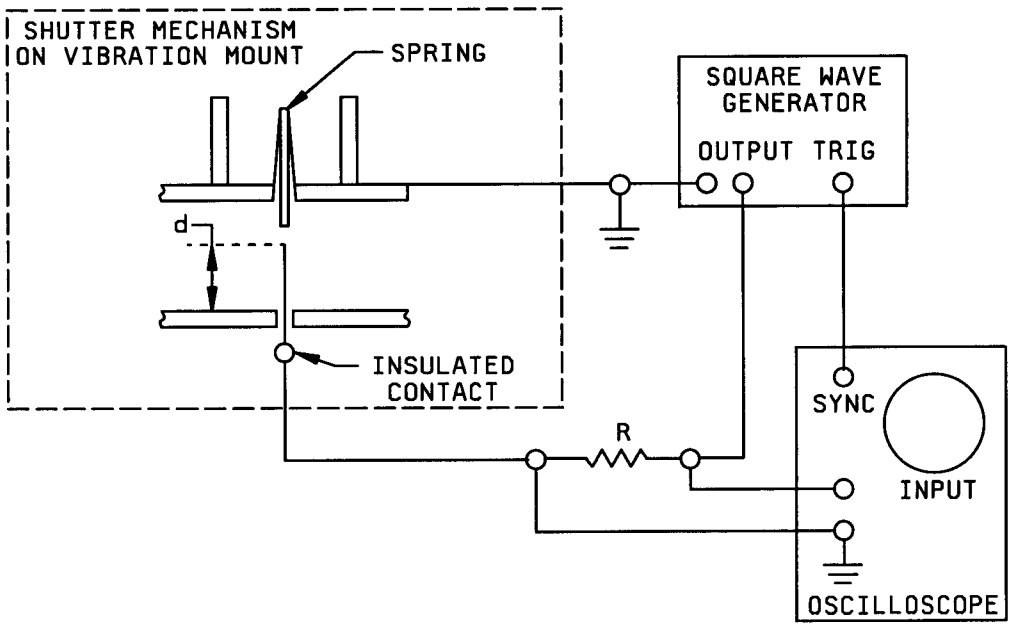


FIGURE 3. Test setup for electrical measurement shutter phase modulation.

g. The shutter is now vibrated through the specified range. Contact with the insulated electrical contact is made whenever the shutter pin travel comes within the distance "d" of the opposing wall. Current will then flow through the resistor "R", and the monitoring oscilloscope will display the waveform of the square-wave generator under vibration.

12/ The current required to hold the shutter open shall be within the specified limit when the tube is subjected to the following shock test: The tubes shall sustain 18-impact shocks (three in each direction of the three mutually perpendicular axes) each shock having a half-sine pulse with perpendicular value 50 g's duration of 11 ± 1 ms. The shutter shall be capable of meeting the requirement over the temperature range extending from -55°C to +125°C.

13/ Unless otherwise specified, the acceptance level for all tests listed under conformance inspection, part 1, shall be 1.0, inspection level II.

14/ Test each section separately.

TABLE I. Testing and inspections - Continued.

15/ The ignitor current noise test is performed in a circuit setup as shown on figure 4. With the rated voltage applied to the shutter and the ignitor, adjust the CW signal from the signal generator to 16.2 GHz. By means of the attenuator, set the crystal current as shown on the meter to 0.5 mA to 0.6 mA. Set the scope internal sweep for 50 µs/cm and the vertical (type H plug in) for 5 mv/cm, or higher. Vary the signal frequency slowly from 15.8 to 17.0 GHz. If the tube under test is noisy, high amplitude, sharp spikes about 10 µs apart will appear on the scope above the "grass" level. If these spikes can be made to disappear by turning the keep-alive voltage off, the tube is noisy and shall be rejected.

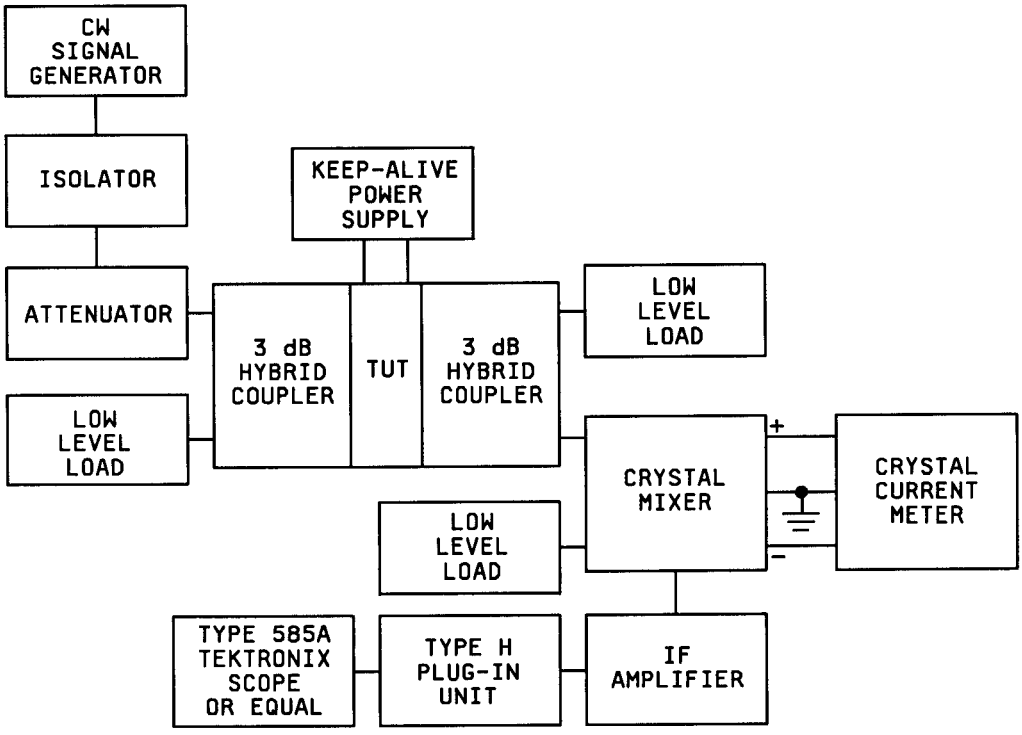


FIGURE 4. Test circuit.

16/ Swept frequency signal may be used for this test.

17/ The leakage power (flat) and leakage energy (spike) shall be measured at the load arm of the duplexer.

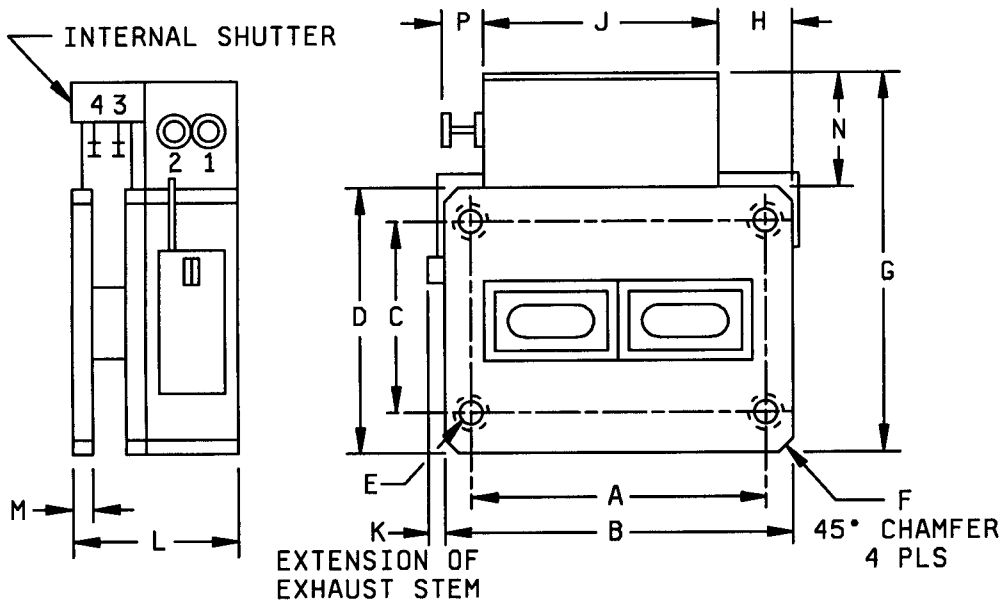
18/ The leakage power (flat) and leakage energy (spike) shall be measured at the receiver arm of the duplexer.

19/ Shutter current shall be measured at rated voltage and 60 seconds after application of this voltage.

20/ Each time the shutters open, a low-level signal is transmitted through the tube and is registered on a counting circuit. At the end of this test, the number of pulses received should equal the number of pulses applied to the shutters.

21/ The crystal noise figure degradation from the initial value shall not exceed the specified limit. One crystal failure will be allowed during the life test. If a crystal failure occurs, a new crystal shall be inserted in the mount and the life test shall continue for a minimum of 100 hours.

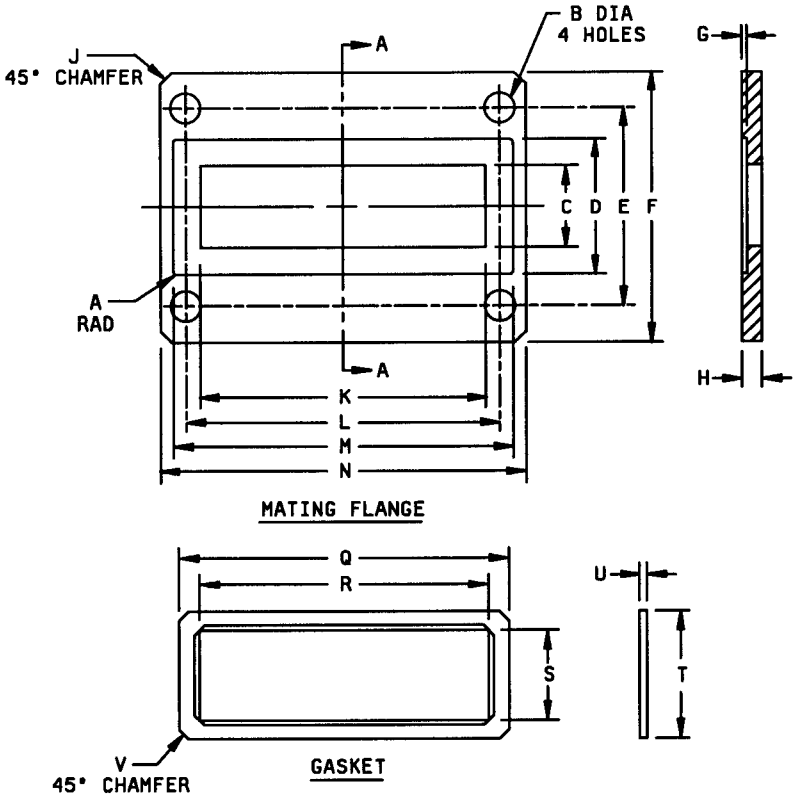
22/ The receiver arm of the duplexer shall be terminated with type 1N78 crystal diodes mounted in a suitable holder and terminated in a dc ground return of 100 ± 10 ohms. At the beginning of the life test, the crystal noise figure (NF) shall meet the minimum requirements for the type 1N78 crystal under the standard, specified conditions. The initial crystal noise figure shall be recorded.



NOTES
1. Exposed length of shutter post terminals (2) shall be .090 inch (2.29 mm) minimum and shall be free of potting and paint.
2. Outside surfaces, except mounting surfaces of flanges, are to be painted using a gloss black epoxy enamel paint.
3. Markings to be stamped with white ink at locations shown in accordance with the requirements of MIL-STD-130.
4. Exhaust tube, tuning screws, and other elements not to extend beyond flange outlines, except where shown.
5. Surface shall be insulated to withstand 50 V dc minimum when applied.
6. Shutters shall be sealed.

Ltr	Dimensions			
	Inches		Millimeters	
	Min	Max	Min	Max
Qualification inspection				
B	1.735	1.765	44.07	44.83
D	1.297	1.327	32.94	33.71
F	.035	.065	0.89	1.65
P	.090	---	2.29	---
Conformance inspection, part 1				
E	No. 6-32 UNC-2B tap through 8 holes			
H	.350	---	8.89	---
J	---	1.250	---	31.75
K	---	.125	---	3.18
L	.803	.805	20.40	20.45
N	---	.500	---	12.70
Conformance inspection, part 2				
A	1.490	1.510	37.85	38.35
C	.951	.961	24.16	24.41
Reference dimensions				
G	---	1.812	---	46.02
M	---	.093	---	2.36

FIGURE 5. Outline drawing of electron tube type DOD-004.



Ltr	Dimensions			
	Inches		Millimeters	
	Min	Max	Min	Max
A	.013	.019	0.33	0.48
B	.142	.152	3.61	3.86
C	.394	.396	10.01	10.06
D	.651	.661	16.54	16.79
E	.952	.960	24.18	24.38
F	1.297	1.328	32.94	33.73
G	.022	.024	0.56	0.61
H	.089	.099	2.26	2.51
J	.045	.065	1.14	1.65
K	1.364	1.366	34.65	34.70
L	1.496	1.504	38.00	38.20
M	1.620	1.630	41.15	41.40
N	1.734	1.766	44.04	44.86
Q	1.563	1.594	39.70	40.49
R	1.379	1.389	35.03	35.28
S	.426	.436	10.82	11.07
T	.594	.625	15.09	15.88
U	.032	.042	0.81	1.07
V	.015	.047	0.38	1.19

FIGURE 6. Outline drawings of mating flange and gasket for tube type DOD-004.

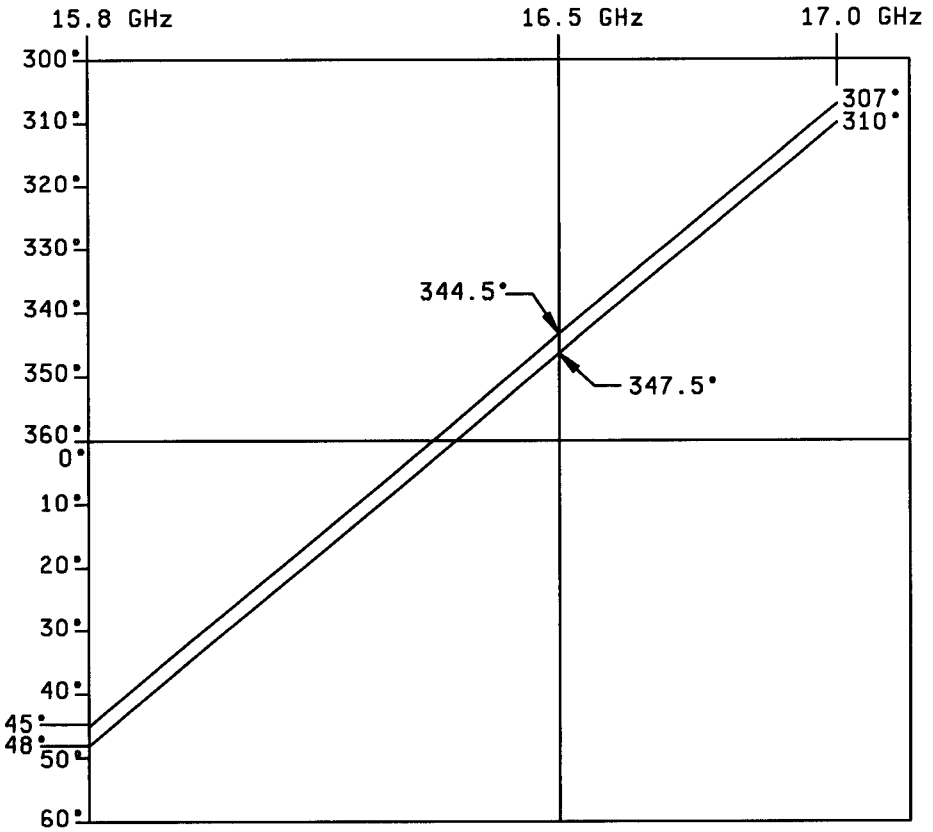


FIGURE 7. Frequency versus degrees phase shift.

Custodians:
Army - CR
Navy - EC
Air Force - 85

Review activities:
Navy - AS, CG, MC, OS
Air Force - 11, 17, 99

Preparing activity:
DLA - CC

(Project 5960-3482)