FULL-WAVE RECTIFIER
MINIATURE TYPE

COATED UNIPOTENTIAL CATHODE
HEATER
6.3 VOLTS 0.60 AMP.
ANY MOUNTING POSITION

GLASS BULB
5-3

THE 6X4WA IS A FULL-WAVE RECTIFIER INTENDED FOR COMMERCIAL AND INDUSTRIAL APPLICATIONS WHERE A HIGH DEGREE OF RELIABILITY IS REQUIRED. IT IS CHARACTERIZED BY LONG LIFE AND STABLE PERFORMANCE UNDER CONDITIONS OF SEVERE VIBRATION, SHOCK, HIGH TEMPERATURE AND HIGH ALTITUDE.

DURABILITY CHARACTERISTICS
IMPACT ACCELERATION (1 MSEC DURATION) (MAX.) 450 G
FATIGUE (VIBRATIONAL ACCELERATION FOR EXTENDED PERIODS) (MAX.) 2.5 G

RATINGS A
ABSOLUTE MAXIMUM
HEATER VOLTAGE B 6.3 ± 10% VOLTS
AC PLATE SUPPLY VOLTAGE, RMS (EACH PLATE) SEE RATING CHART 1
STEADY STATE PEAK PLATE CURRENT, RATING CHART 2 (EACH PLATE) 220 MA.
TRANSIENT PEAK PLATE CURRENT, RATING CHART 3 (EACH PLATE) D 1.6 AMP.
DC OUTPUT CURRENT (EACH PLATE) SEE RATING CHART 1
HEATER-CATHODE VOLTAGE:
HEATER NEGATIVE WITH RESPECT TO CATHODE
TOTAL DC AND PEAK 450 VOLTS
HEATER POSITIVE WITH RESPECT TO CATHODE
TOTAL DC AND PEAK 100 VOLTS
BULB TEMPERATURE 165 °C
ALTITUDE C

CHARACTERISTICS E
FULL-WAVE RECTIFIER-CAPACITOR INPUT
AC PLATE SUPPLY VOLTAGE PER PLATE 400 VAC
FILTER INPUT CAPACITOR 8 μF
LOAD RESISTOR 8200 OHMS
DC OUTPUT CURRENT 55 MA DC
DC OUTPUT VOLTAGE AT FILTER INPUT (APPROX.) 435 VDC
TUBE VOLTAGE DROP E
Ib = 50 MA EACH PLATE 22 VOLTS

CONTINUED ON FOLLOWING PAGE
CONTINUED FROM PRECEDING PAGE

NOTES

A LIMITATIONS BEYOND WHICH NORMAL TUBE PERFORMANCE AND TUBE LIFE MAY BE IMPAIRED.

B IF ALTITUDE RATING IS EXCEEDED, REDUCTION OF INSTANTANEOUS VOLTAGES (IF EXCLUDED) MAY BE REQUIRED.

C TUBE LIFE AND RELIABILITY OF PERFORMANCE ARE DIRECTLY RELATED TO THE DEGREE OF REGULATION OF THE HEATER VOLTAGE TO ITS CENTER-RATED VALUE.

D IF CAPACITOR INPUT CIRCUITS ARE TO BE USED, PROTECT THE CIRCUITS AGAINST THE POSSIBILITY OF HOT-SWITCHING AND DO NOT EXCEED A MAXIMUM PEAK CURRENT VALUE OF 1.6 AMPERE DURING THE INITIAL CYCLES OF THE HOT-SWITCHING TRANSIENT.

E TEST CONDITIONS ONLY.

INTERPRETATION OF RATING CHARTS

RATING CHARTS 1, 2 AND 3 REPRESENT BOUNDARY CONDITIONS BEYOND WHICH OPERATION IS NOT PERMITTED. WITH THE AID OF SIMPLE LABORATORY MEASUREMENTS AND THE USE OF THE THREE CHARTS, ANY APPLICATION MAY BE ANALYZED FOR PROPER RECTIFIER TYPE OPERATION.

THE BOUNDARIES OF RATING CHART 1 ARE BASED ON LIMITS OF SUPPLY VOLTAGE, PLATE DISSIPATION AND OUTPUT CURRENT. THESE BOUNDARIES DIFFER, DEPENDING UPON THE TYPE OF FILTER USED. WITH CAPACITOR INPUT, OPERATION IS CONFINED TO THE AREA BOUNDED BY FABCD. WHILE FOR CHOKE INPUT, THE ENTIRE AREA BOUNDED BY FABCD MAY BE USED.

THE BOUNDARY OF RATING CHART 2 DEFINES THE LIMIT OF STEADY-STATE PEAK CURRENT. OPERATION WITHIN THE BOUNDARY IS PERMITTED.

RATING CHART 3 DEFINES THE MINIMUM VALUE OF EFFECTIVE PLATE SUPPLY RESISTANCE, PER PLATE, FOR ANY GIVEN PLATE VOLTAGE SUPPLY WHICH WILL ASSURE THAT THE SURGE CURRENTS ARE WITHIN A SAFE VALUE.

\[
R_s = N^2 R_{pri} + R_{sec} + R_a
\]

WHERE: \(N\) - VOLTAGE STEP UP RATIO OF PLATE TRANSFORMER:

\[
N = \frac{N_{Secondary}}{N_{Primary}} \text{ for half-wave}
\]

\[
N = \frac{N_{Secondary}}{2N_{Primary}} \text{ for full-wave}
\]

\(R_{pri}\) - DC RESISTANCE OF TRANSFORMER PRIMARY.

\(R_{sec}\) - AVERAGE DC RESISTANCE OF TRANSFORMER SECONDARY PER SECTION.

\(R_a\) - ADDED SERIES RESISTANCE.

FOR ANY APPLICATION, EACH CHART SHOULD BE CONSULTED. ON ALL CHARTS THE POINTS OF OPERATION SHOULD FALL WITHIN THE PROPER BOUNDARIES.

PLATE SUPPLY VOLTAGES ARE MEASURED WITH THE RECTIFIER TUBE NON-CONDUCTING, I.E., WITH THE TRANSFORMER UNLOADED. THIS UNLOADED VOLTAGE IS USED WITH CALCULATING RECTIFICATION EFFICIENCY.

THE RECTIFICATION EFFICIENCY IS DEFINED AS:

\[
\text{DC OUTPUT VOLTAGE} \div \text{(UNLOADED RMS SUPPLY VOLTAGE PER PLATE)}
\]

THE DC OUTPUT VOLTAGE IS MEASURED AT THE INPUT TO THE FILTER

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## ACCEPTANCE CRITERIA

<table>
<thead>
<tr>
<th>TABLE 1 REF.</th>
<th>AQL %</th>
<th>MIN. LIMITS</th>
<th>BOG.</th>
<th>MAX. LIMITS</th>
<th>UNITS</th>
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<tbody>
<tr>
<td>HEATER CURRENT</td>
<td>4.10.8</td>
<td>1.0</td>
<td>540</td>
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<tr>
<td>HEATER-CATHODE LEAKAGE: Ekk=450 Vdc</td>
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<td>75</td>
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<td>OPERATION: NOTE 5 Io \ Ekk=540 Vdc</td>
<td>4.10.13</td>
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<tr>
<td>EMMISSION (i): NOTE 2, Is \ Eb = 50 Vdc</td>
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<td>1.0</td>
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<tr>
<td>CONTINUITY AND SHORTS: \ NOTE 7</td>
<td>---</td>
<td>0.4</td>
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<tr>
<td>MECHANICAL: ENVELOPE (6-5)</td>
<td>4.9.1</td>
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<tr>
<td>INSULATION OF ELECTRODES: \ NOTE 2 Ep=540 Vdc, Rp=5000</td>
<td>4.8</td>
<td>2.5</td>
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<tr>
<td>\ Rp=5000</td>
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<tr>
<td>EMMISSION (2); Is \ Ef=5 V, Ed=50 Vdc</td>
<td>4.10.11</td>
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<tr>
<td>LOW PRESSURE VOLTAGE BREAKDOWN: \ PRESSURE = 14005 mm Hg; VOLTAGE = 980 Vac</td>
<td>4.9.12.1</td>
<td>6.5</td>
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<tr>
<td>VIBRATION (i): NO VOLTAGES; F=40 cps; q=10</td>
<td>4.9.19.1</td>
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## DEGRADATION RATE ACCEPTANCE TESTS - NOTE 3

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<th>TABLE 1 REF.</th>
<th>AQL %</th>
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<th>BOG.</th>
<th>MAX. LIMITS</th>
<th>UNITS</th>
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<tbody>
<tr>
<td>SHOCK: \ HAMMER ANGLE = 30° (450 G, 4 msec DURATION); Epp/p= \ O V; Ef = 6.5 V</td>
<td>4.9.20.5</td>
<td>20</td>
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<tr>
<td>FATIGUE: \ G= 2.5; FIXED FREQUENCY; F = 25 cps min.; 60 max.</td>
<td>4.9.20.6</td>
<td>6.5</td>
<td>96</td>
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<tr>
<td>POST SHOCK AND FATIGUE TEST END POINTS: \ HEATER-CATHODE LEAKAGE, Ekk=450 Vdc</td>
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<td>OPERATION, Io; NOTE 5</td>
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<td>GLASS STRAIN</td>
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### Acceptance Criteria

#### Acceptance Life Tests

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<th>MIL-E-1 REF.</th>
<th>AQL %</th>
<th>1st SAMPL.</th>
<th>SAMPL. LIMITS</th>
<th>MIN.</th>
<th>MAX.</th>
<th>UNITS</th>
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<tr>
<td>HEATER CYCLING LIFE TEST (2000 CYCLES MIN.)</td>
<td>4.11.7</td>
<td>4.11.4</td>
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<td>150</td>
<td>µA/dc</td>
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<tr>
<td>Ef = 7.5V; t min. on, t min. off; Epk=±400 Vdc; Epp/p = 0 V</td>
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<td>---</td>
<td>100</td>
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<td>HOURS</td>
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<td>---</td>
<td>51</td>
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<td>mA/dc</td>
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<td>HEATER- Cathode Leakage, Ehk = -450 Vdc</td>
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<td>500</td>
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<td>HOURS</td>
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<td>4.11.4</td>
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<td>8.5</td>
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<td>EMISSION (µA)</td>
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<td>540</td>
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<td>INTERMITTENT LIFE TEST POINTS</td>
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<td>SURVIVAL RATE LIFE TEST CONDITIONS:</td>
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<td>T Envelope = +165°C min.;</td>
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<td>4000 HOUR REQUIREMENTS DO NOT APPLY</td>
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<td>µA/dc</td>
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<tr>
<td>INOPERATIVE (NOTE 1)</td>
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<td>OPERATION - CHANGE OF INDIVIDUALS Δ i0</td>
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<td>1</td>
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<tr>
<td>HEATER CURRENT</td>
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<td>540</td>
<td>670 mA</td>
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<td>HEATER-CATHODE LEAKAGE</td>
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<tr>
<td>Ehk = -450 Vdc</td>
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<td>2</td>
<td>5</td>
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</tr>
</tbody>
</table>

### Acceptance Criteria Notes

1. An inoperative is defined as a tube having one or more of the following defects: discontinuity or short (Ref. Note 1 except tubes shall not be tapped); air leaks (Ref. MIL-E-1, Par. 4.1.6.1).

2. Test each section separately.

3. Tubes subjected to the following destructive tests are not to be accepted under this specification.

   4.9.20.5 SMOKE
   4.9.20.6 FATIGUE
   4.11.7 HEATER CYCLING LIFE TEST
   4.11.3.2 INTERMITTENT LIFE TEST

CONTINUED ON FOLLOWING PAGE
ACCEPTANCE CRITERIA NOTES - cont'd.

4. ENVELOPE TEMPERATURE IS DEFINED AS THE HIGHEST TEMPERATURE INDICATED WHEN USING A THERMO-COUPLE OF NO. 85 OR SMALLER DIAMETER ELEMENTS WELDED TO A RING OF 0.025 INCH DIAMETER PHOSPHOR BRONZE PLACED IN CONTACT WITH THE ENVELOPE. ENVELOPE TEMPERATURE REQUIREMENT WILL BE SATISFIED IF A TUBE, HAVING BOGEY 1B 1/8" X 1.5" UNDER NORMAL TEST CONDITIONS, IS DETERMINED TO OPERATE AT MAXIMUM SPECIFIED TEMPERATURE AT ANY POSITION ON THE LIFE TEST RACK.

5. IN A FULL-WAVE CIRCUIT, ADJUST P/P SO THAT A BOGEY TUBE GIVES Ic = 55 mA. A BOGEY TUBE HAS A TUBE DROP Etd = 22 Vdc AT Ic = 50 mA PER PLATE.

6. IN A FULL-WAVE TEST CIRCUIT, THE VALUES SPECIFIED FOR RL & CL MAY BE CONSIDERED APPROXIMATE AND SHALL BE ADJUSTED INITIALLY TO GIVE NOT LESS THAN Ic = 75 mA DC AND Ic = 200 mA PER PLATE WITH A BOGEY TUBE. Eh=Ko = 117 Vdc.

7. ALL TUBES SHALL BE TESTED FOR CONTINUITY OF ALL CIRCUITS, INCLUDING DUPLICATE PIN CONNECTIONS TO THE SAME ELECTRODE; FOR SHORTS BETWEEN ANY OF THE TUBE ELEMENTS OR BETWEEN THE ELEMENTS AND THE NO-CONNECTON BASE PINS; AND FOR AIR LEAKS.

TESTS FOR SHORTS SHALL BE PERFORMED USING AN AUTOMATIC TAPPER DESIGNED AND ADJUSTED TO DELIVER AN IMPULSE OF APPROXIMATELY ONE-HALF SINE WAVE OF 3900/500 USEC DURATION (MEASURED 10% FROM THE BASE OF THE TUBE UNDER TEST) AND HAVING A PEAK ACCELERATION OF 60 GTS AS MEASURED WITH A GULTON A-105 ACCELEROMETER AND KA-1 KIT. THE SHORTS DETECTING EQUIPMENT SHALL BE A DC DEVICE CAPABLE OF DETECTING AS SHORTS INTERELECENCY RESISTANCES WHICH PERsist FOR A PERIOD OF TIME IN EXCESS OF THAT DETERMINED BY A CURVE OF RESISTANCE VERSUS TIME DURATION PASSING THROUGH THE FOLLOWING POINTS: 600,000 OHMS - CONSTANT VALUE (PERMANENT SHORT); 500,000 OHMS - 500 USEC; 100,000 OHMS - 100 USEC; AND 1,000 OHMS - 60 USEC.

THE TUBE UNDER TEST SHALL BE CONNECTED TO THE SHORTS EQUIPMENT WITH ELEMENTS IN SEQUENCE FOR SINGLE SECTION TUBES BUT LIKE ELEMENTS IN THE SECTIONS OF A MULTISECTION TUBE MAY BE PARALLELED, PROVIDING THE MECHANICAL ASSEMBLY OF THE TUBE STRUCTURE IS SUCH THAT THE POSSIBILIT Y OF A SHORT DUE TO SECTION CROSS JUMPERS IS REMOTE.

TUBES HAVING PERMANENT SHORTS, OPEN AND AIR LEAKS SHALL BE REJECTED ON THE FIRST TEST, IF REJECTED FOR TAP-SHORT OR OPEN OCCURS ON FIRST SERIES OF TAPS REPEAT TAPPING CYCLE THREE TIMES. REJECT TUBE AS INOPERABLE IF REJECT OCCURS AT ANY TIME DURING THE THREE REPEAT TEST, OTHERWISE ACCEPT.

8. FOR SURVIVAL RATE LIFE TEST THE SAMPLING AND TESTING SHALL BE AS SPECIFIED IN 20.2.5.2 TO 20.2.5.4 INCLUSIVE OF APP. C. WITH THE FOLLOWING EXCEPTIONS: 20.2.5.3 - REPLACE THE LAST SENTENCE WITH "IF SUCH SELECTION RESULTS IN A SAMPLE CONTAINING ONE OR MORE TUBES WHICH ARE DEFFECTIVE WHEN TESTED UNDER CONDITIONS OF INITIAL SHORT AND CONTINUITY TEST (REF. NOTE 7) SUCH TUBES SHALL BE REPLACED BY RANDOMLY SELECTED 500 TUBES." 20.2.5.4(1): REPLACE WITH "UPON COMPLETION OF 100 HOURS, THE TUBES SHALL AGAIN BE SUBJECTED TO THE SHORT AND CONTINUITY TEST (REF. NOTE 7)."
TENTATIVE DATA

6X4WA

$E_f = 6.3$ Volts

$C = 4 \mu F$

$R_s = 175$ Ohms (Curves 1-5)

$R_s = 295$ Ohms (Curves 6-9)

FULL-WAVE RECTIFIER
CAPACITOR-INPUT FILTER
(Boundary line DEA is Same as Shown on Rating Chart 1)

DC OUTPUT VOLTS AT INPUT TO FILTERS

DC LOAD CURRENT IN MA

RATING CHART 1
6X4WA

$E_f = 6.3$ Volts

AC PLATE - SUPPLY VOLTS PER PLATE (RMS) IN VOLTS

DC OUTPUT CURRENT EACH PLATE IN MILLIAMPERES

TUNG-SOL ELECTRIC INC., ELECTRON TUBE DIVISION, BLOOMFIELD, NEW JERSEY, U.S.A. OCTOBER 1, 1960 PLATE #6012
RATING CHART II
6X4WA
$E_f = 6.3$ Volts

FOR CAPACITOR - INPUT FILTER
(BASE ON MAXIMUM STEADY-STATE PEAK PLATE CURRENT OF 220 MA PER PLATE)

DC OUTPUT CURRENT EACH PLATE IN MA.

RECTIFICATION EFFICIENCY

RATING CHART III
6X4WA
$E_f = 6.3$ Volts

FOR CAPACITOR-INPUT FILTER
(BASE ON MAXIMUM TRANSIENT PEAK PLATE CURRENT OF 1.6 AMPERES PER PLATE)

MINIMUM PLATE-SUPPLY RESISTANCE PER PLATE (R$$_S$$) IN OHMS

AC PLATE-SUPPLY VOLTAGE PER PLATE (RMS) IN VOLTS