

MULTI-PHASE COOLED POWER TETRODE 4CM2500KG

The EIMAC 4CM2500KG is a ceramic/metal, multi-phase (water/vapor) cooled power tetrode designed for very high power rf service.

The 4CM2500KG has a high density thoriated tungsten mesh filament mounted on water-cooled supports. Pyrolytic graphite control and screen grids are used to provide stability at high dissipation. The maximum anode dissipation rating is 2500 kilowatts.

Large diameter coaxial control grid and cathode terminals allow enhanced VHF performance. Filament power and filament support cooling water are supplied through connectors which allow for quick tube installation and replacement.



CHARACTERISTICS¹

ELECTRICAL

Filament: Thoriated Tungsten Mesh

Voltage 15.5 V

Current at 15.5 Volts (nominal) 640 A

Frequency of Maximum Ratings (CW) 130 MHz

Maximum Useful Frequency Over 200 MHz

Amplification Factor, Average, Grid to Screen 6

Direct Interelectrode Capacitances (grounded cathode):

C_{in} 1110 pF

C_{out} 150 pF

C_{gp} 5.5 pF

Direct Interelectrode Capacitances (grounded grid and screen)²

C_{in} 385 pF

C_{out} 152 pF

C_{pk} 0.07 pF

MECHANICAL:

Net Weight 161 lb.; 73.0 kg

Gross Weight 340 lbs; 154 kg

Operating Position Vertical, Base Down

Cooling Water and Forced Air

Maximum Overall Dimensions:

Length 18.75 in; 47.62 cm

Diameter 17.03 in; 43.26 cm

Maximum Operating Temperature,

Envelope and Ceramic/Metal Seals 200°C

Available Filament Power Connectors (not supplied with tube):

Filament Power/Water Connector (2 required):

EIMAC SK-2310

Filament rf Connector (1 required):

EIMAC SK-2315

Available Anode Cooling Water Connectors (not supplied with tube):

Note: 2 connectors are required per tube

EIMAC SK-2322 or EIMAC SK-2323

The values listed above represent specified limits for the product and are subject to change. The data should be used for basic information only. Formal, controlled specifications may be obtained from CPI for use in equipment design.



For information on this and other CPI products, visit our website at: www.cpii.com, or contact: CPI MPP, Eimac Operation, 607 Hansen Way, Palo Alto, CA 94303

TELEPHONE: 1(800) 414-8823. **FAX:** (650) 592-9988 | **EMAIL:** powergrid@cpii.com

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RADIO FREQUENCY POWER AMPLIFIER

GROUNDING - Drive Pulsed

For long pulse fusion applications or CW Service (Class AB or B)

ABSOLUTE MAXIMUM RATINGS:

DC ANODE VOLTAGE	27	kilovolts
DC SCREEN VOLTAGE	2.5	kilovolts
ANODE CURRENT #	190	amperes
ANODE DISSIPATION	2500	kilowatts
SCREEN DISSIPATION	20	kilowatts
GRID DISSIPATION	8.0	kilowatts

TYPICAL OPERATION:

ANODE-TO-GRID VOLTAGE	24	24	24	kVdc
SCREEN-TO-GRID	1000	1500	2000	Vdc
BIAS VOLTAGE	490	500	540	Vdc
ANODE CURRENT #	86.7	127	182	Adc
ANODE DISSIPATION	441	728	1550	kW
SCREEN CURRENT #	5.8	7.5	4.1	Adc
SCREEN DISSIPATION	10.1	16.9	11.3	kW
GRID CURRENT #	10.3	10.0	6.1	Adc
DRIVE POWER #	69.9	98.3	138.0	Kw
ANODE LOAD IMPEDANCE	145	102	74	Ohms
POWER OUTPUT #*	1700	2400	3500	kW

Average during the pulse

* Approximate

APPLICATION

MECHANICAL

UNPACKING – To insure safety of the operator performing the work as well as preventing damage to the tube, the following instructions should be followed:

- 1) Open the crate by removing the lid, first unlocking the toggle bolts in 8 places.
- 2) Attach a lifting hoist to the lifting loop and raise the tube slightly with mounting brackets attached to support the weight of the tube.
- 3) Remove 8 bolts securing the mounting brackets to the corners.
- 4) Using the hoist, lift the tube and place on blocks or on a stand that supports its weight by the bottom of the lower corona ring.
- 5) Remove the brackets from the tube.

HANDLING – This product contains a thoriated-tungsten filament, and although of a rugged mesh design, it is relatively fragile and a tube should be protected from shock and vibration. A lifting eye is available at the center of the anode cooler and should be used any time the tube is to be lifted for moving, etc. A lifting device such as a chain hoist may be

employed to lift the tube and should be capable of safely supporting the full weight of the tube (up to 200 lbs with cooling water in the anode cooler) and should be operated with great care, especially when lowering the tube onto a resting place or into equipment. It is recommended that a thick rubber mat or similar material be used to absorb any undue shock that may occur if the tube is to be placed temporarily on a hard surface.

STORAGE – If a tube is to be stored as a spare it should be kept in its shipping crate and all water should be purged from the anode cooler and from the filament supports/connectors. The anode cooler can be drained by inverting the tube. Water should be purged from the internal filament support structure by applying compressed air to one of the filament coolant ports and it is important to note that pressure during this process must be limited to 2 Bar (29 psi). Under no circumstances should one attempt to use an unregulated air source for this procedure.

The tube should be stored with a portable VAC-ION pump power supply connected to allow monitoring the vacuum tubes vacuum properties (see section on VACION PUMP OPERATION for details.)



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The original shipping crate with the shock mounts and hardware should be retained in a dry place for future use such as moving a tube over a considerable distance. Instructions on affixing the shock mounts is included with each tube.

MOUNTING - The 4CM2500KG must be mounted vertically, base down. The full weight of the tube should rest on the screen-grid contact flange at the base of the tube, and all lifting of the tube should be done with the lifting eye which is attached to the top of the anode cooling jacket.

ANODE COOLING - The anode is cooled by circulating high velocity water near the boiling point through the structure. The inlet and outlet connections are clearly marked on top of the anode cooling jacket and it is important they be connected only as indicated. Multiphase cooling provides efficient removal of heat from the anode and assures additional capacity for temporary overloads.

Tube life can be seriously compromised by the condition of the cooling water. If it becomes contaminated, deposits will form on the inside of the water jacket causing localized anode heating and eventual tube failure. To insure minimum electrolysis and power loss, the water resistance at 25°C should always be one megohm per cubic centimeter or higher. The relative water resistance should be periodically checked using readily available instruments.

High velocity water flow is required to maintain high thermal efficiency; for this reason operation at lower anode dissipation using lower flow rates than what is listed in the table on p.3 is not recommended.

Cooling water must be well filtered, with effectiveness the equivalent of a 100-mesh screen, to eliminate any solid material and avoid the possibility of blockage of any cooling passages, as this would immediately affect cooling efficiency and could produce localized anode overheating and failure of the tube.

Minimum water flow requirements for the anode are shown in the table for an outlet water temperature not to exceed 100°C and inlet water temperature

at 49°C. System pressure should not exceed 100 psi.

Anode Dissipation (kW)	Water Flow (gpm)	Approx. Jacket Press Drop (psi)
2500	200	87

This cooling data is applicable to steady-state or transient anode dissipation. At significantly reduced anode dissipation a lower flow rate may be permissible but using the maximum flow rate will protect the tube from unforeseen events that may cause surges in anode dissipation.

EIMAC Application Bulletin #16, WATER PURITY REQUIREMENTS IN LIQUID COOLING SYSTEMS, is available on request and contains considerable detail on purity requirements and maintenance systems.

BASE COOLING - The tube base requires air cooling with a minimum of 50 cfm of air at 50°C maximum at sea level, directed toward the base seal areas from a general purpose fan. It should be noted that temperatures of the ceramic/metal seals and the lower envelope areas are the controlling and final limiting factor. Temperature-sensitive paints are available for use in checking temperatures in these areas before equipment design and air-cooling requirements are finalized. EIMAC Application Bulletin AB-20, MEASURING TEMPERATURE OF POWER GRID TUBES, covers this subject in detail and is available on request.

Water cooling of the filament and screen grid supports is also required, with inlet water temperature not to exceed 49°C. Each of the two filament connectors include both an inlet and an outlet line, with the proper connector for the inlet water shown on the tube outline drawing. Minimum flow for the F1 connector is 2.0 gpm, at an approximate pressure drop of 12 psi. Minimum flow for the F2 connector is 4.0 gpm, at an approximate pressure drop of 50 psi. The screen grid cooling water is fed by means of ¼-18 NPT tapped holes shown on the tube outline drawing, with a minimum flow of 2.0 gpm required, at an approximate pressure drop of 12 psi.

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ALL COOLING MUST BE APPLIED BEFORE OR SIMULTANEOUSLY WITH THE APPLICATION OF ELECTRODE VOLTAGES, INCLUDING THE FILAMENT, AND SHOULD NORMALLY BE MAINTAINED FOR SEVERAL MINUTES AFTER ALL VOLTAGES ARE REMOVED TO ALLOW FOR TUBE COOLDOWN.

ELECTRICAL

ABSOLUTE MAXIMUM RATINGS - Values shown for each type of service are based on the "absolute system" and are not to be exceeded under any service conditions. These ratings are limited values outside which serviceability of the tube may be impaired. In order not to exceed absolute ratings the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by a safety factor so that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself. It does not necessarily follow that combinations of absolute maximum ratings can be attained simultaneously.

HIGH VOLTAGE - Normal voltages used with this tube are deadly, and equipment must be designed properly and operating precautions followed. Design all equipment so that no one can come in contact with high voltages. Equipment must include safety enclosures for the high-voltage circuits and terminals, with interlock switches to open primary circuits of the power supply and to discharge high voltage capacitors when access doors are opened. Interlock switches must not be bypassed to allow operating with access doors open. Always remember that **HIGH VOLTAGE CAN KILL**.

FILAMENT OPERATION - Filament turn-on and turn-off should be programmed. Filament voltage should be smoothly increased from zero to the operating level over a period of two minutes, and a motor-driven continuously variable auto-transformer (such as a VARIAC® or a POWERSTAT®) is suggested. Inrush current must never be allowed to exceed twice normal operating current. Normal turnoff procedure should be a smooth decrease from the operating voltage to zero over a period of two minutes.

During periods of standby service, filament life may be increased by a small reduction in filament voltage. Black heat operation (a reduction of filament voltage to 50% or less of nominal voltage) is prohibited. During standby periods, forced air cooling and water flow must be maintained on the filament supports to ensure the ceramic/metal seal temperature does not exceed 200°C. In addition, anode cooling water flow must be maintained at a rate that ensures the outlet water temperature never exceeds 100°C. See cautionary information regarding hot water on p.5. Serious damage and personal harm can result if water flow is interrupted while power is applied to the filament therefore system interlocks are necessary to remove all power to the tube if coolant flow is not present for any reason. Filament voltage should be measured at the tube base, using an accurate rms-responding meter.

Where hum is an important system consideration, it is permissible to operate the filaments with dc rather than ac power. Contact CPI Microwave Power Products, EIMAC Operation Application Engineering for special precautions when using a dc filament supply.

Care should be exercised to keep any rf power out of the filament of the tube, as this can cause excessive operating temperatures. Both sides of the filament must be bypassed to assure monopotential operation. It should be ascertained that no resonance exists in the filament circuit which could be excited during operation. When this tube is operated at combined screen and grid dissipations above 10 kilowatts the filament power should be reduced to maintain proper filament temperature (i.e., resistance) and thereby assure optimum life. Contact CPI Microwave Power Products, EIMAC Operation Applications Engineering for specific recommendations.

This tube is designed for commercial service, with only one off/on filament cycle per day. If additional on/off cycling of filament power is anticipated it is recommended the user contact CPI Microwave Power Products, EIMAC Operation Applications Engineering for additional information. **VACION® PUMP OPERATION** – The tube is supplied with an ion pump and magnet, permanently mounted on the filament structure at the base (stem). The primary func-



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tion of this device is to allow monitoring of the condition of the tube vacuum, as shown by an ion current meter.

With an operational tube it is recommended the VAC-ION pump be operated full time so tube vacuum may be monitored on a continuous basis. A reading of less than 10 uAdc should be considered as normal, indicating excellent tube vacuum. In addition to other interlock circuitry it is recommended that full advantage be taken of the VACION pump readout by providing circuitry which will shut down all power to the tube in the event the readout current exceeds 50 uAdc. In the event of such a shutdown, the VACION pump should be operated alone until vacuum recovery is indicated by a reading of 10 uAdc or less, at which point the tube may again be made operational. If the vacuum current rises again it should be considered as indicating a circuit problem such as some tube element may be over-dissipating and outgassing.

The VACION pump requires a positive voltage applied to the center pin of approx. 3000 Vdc to operate properly.

One source for VACION power supplies is Varian, Inc. Varian's web site www.varianinc.com has several models which may be suitable for use with the 4CM2500KG. Varian model 9290200 (120 volt ac line) or 9290201 (220 Volt ac line) appear suitable. Alternatives for Varian power supplies are: HeatWave Labs <http://www.cathode.com/> and Duniway Stockroom <http://www.duniway.com/>

At the tetrode a coaxial cable is attached to the VACION pump and comes attached to the tube as delivered. This cable assy. includes a resistor that prevents the filament current from being shorted to ground. The end of the resistor has a solder lug that is attached using one of the small screws to the magnet assy at the VACION pump. The other end of this cable has a female receptacle (type MHV, also designated mil. UG-1016A/U or Amphenol type 27075).

To plug onto this receptacle a male plug type UG-932/U, also supplied with each tube, is normally used for making up an extender cable of the required length. The other end of the extender cable goes to the VACION power supply; the Varian supplies require a Kings plug

1065-1 (not supplied with the 4CM2500KG). For info see: <http://www.kingselectronics.com/> and cable type RG-58A/U or Belden 8259 is recommended for this connector.

In the case of a tube being held as a spare, it is recommended the VACION pump be operated continuously if possible, otherwise it should be operated periodically to check the condition of tube vacuum and operated as long as necessary to achieve a reading of 10 uAdc or lower.

Figure 1 shows the relationship between tube vacuum and the ion current reading. Electrode voltages, including filament voltage, should never be applied if a reading of 50 uAdc or higher is obtained. In the event that poor vacuum cannot be improved by operation of the VACION pump the user should contact CPI Microwave Power Products, EIMAC Operation and review the details with an Applications Engineer. If the tetrode is grid-driven the cathode (and therefore the filament power supply) is generally referenced to dc ground potential, that is no bias voltage or other voltage is supplied to the filament. In this case the VACION power supply may be used with no isolation and the shield and connector on the VACION cable should be grounded for reasons of electrical safety. If however the tetrode is to be used in grounded-grid (cathode-driven) configuration as is typical in the case of VHF, then rf drive applied to the tube's cathode/filament will also be present on the VACION cable and therefore good rf isolation must be provided to prevent rf power from flowing on this cable. The system designer must therefore incorporate rf filtering on the VACION cable to keep rf energy from passing back into the VACION power supply and its metering circuit; ferrite chokes around the cable may be suitable. The filament supply should be grounded as any dc voltage that is applied from the filament to ground will interfere with proper VACION operation.

ANODE OPERATION - The maximum anode dissipation rating of 2500 kilowatts should not be exceeded even for very brief periods during setup or tuning. Anode current which flows at high anode voltages with no rf, such as interpulse idling current, must be avoided

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by such means as reducing screen voltage or increasing control grid bias during the “idling” period. Current flowing at high anode voltage causes significant X-Ray generation. At typical Class AB idling currents X-Ray intensity is very high and represents a significant potential hazard to personnel in the vicinity of the tetrode. See X-RADIATION HAZARD on p.7 for more information.

Operation with low values of anode current under some conditions of high instantaneous anode voltage (such as regulator service or lower power and low impedance “tuning” conditions) can, as a result of the screen and grid voltages chosen, lead to anode damage and subsequent failure from spot heating as a result of focusing effects in the tube. If operation under such conditions is necessary CPI Microwave Power Products, EIMAC Operation’s Application Engineering should be contacted for assistance in selection of operating parameters. **GRID OPERATION** - The maximum grid dissipation is 8 kilowatts and protective measures should be taken to insure that this rating is not exceeded. Grid dissipation is approximately equal to the product of dc grid current and peak positive grid voltage. A protective spark gap device should be connected between the control grid and the cathode to guard against excessive voltage.

Under some operating conditions the control grid may exhibit a negative resistance characteristic. This may occur with high screen voltage when increasing the drive power results in a net decrease in grid current. Large values of negative grid current can cause the amplifier to become regenerative. The driver stage must be designed to tolerate this condition. One technique is to swamp the driver so that the change in load, due to secondary grid emission, is a small percentage of the total driver load.

SCREEN OPERATION - The maximum screen grid dissipation is 20 kilowatts. With no ac applied to the screen grid, dissipation is simply the product of dc screen voltage and the dc screen current. Rf heating of the screen must be measured in calculating total screen dissipation at frequencies greater than 60 MHz. Anode voltage, anode loading, or bias voltage must never be removed while filament and screen voltages are present, since

screen dissipation ratings will be exceeded. Suitable protective circuitry must be provided to remove screen power in case of a fault condition. A protective spark-gap device should be connected between screen grid and the cathode to guard against excessive voltage.

Operation of the 4CM2500KG at its maximum VHF power capabilities will result in sufficient rf current screen grid heating to cause significant reverse screen grid current due to thermionic emission. Such operation will not cause tube damage if proper procedures are followed; however, the screen grid circuit must be designed with this characteristic in mind so that the correct operating voltage will be maintained on the screen under all conditions. Dangerously high anode current may flow if the screen power supply exhibits a rising voltage characteristic with negative screen current. A current path from the screen to cathode must be provided by a bleeder resistor to absorb the reverse current without allowing the screen grid voltage to rise excessively. A series-regulated power supply can only be used when an adequate bleed-resistor is provided; a shunt-regulated power supply is also very effective towards meeting this requirement.

PULSE OPERATION - The thermal time constants of the internal tube elements vary from a few milliseconds in the case of the grids to about 200 milliseconds for the anode. In many applications the meaning of duty as applied to a pulse chain is lost because the interpulse period is very long. For pulse lengths greater than 10 milliseconds, where the interpulse period is more than 10 times the pulse duration, the element dissipations and required cooling are governed by the watt-seconds during the pulse. Provided the watt-seconds are less than the listed maximum dissipation rating and sufficient cooling is supplied, tube life will not be compromised. To maintain high cooling efficiency the anode water flow must be sufficient to insure turbulent flow. See Flow Recommendation on Page 3. **FAULT PROTECTION** - In addition to the normal anode over-current interlock and coolant interlock, the tube must be protected from internal damage caused by any arc which may occur. A protective resistance should always be connected in series with the grid and anode to help absorb power supply stored energy if an arc should occur.

An electronic crowbar, which will discharge power supply capacitors in a few microseconds after the start of an arc, is required. The protection criteria for each supply is to short each electrode to ground, one at a time, through a vacuum relay switch and a 6-inch length of #30 AWG copper wire. The wire will remain intact if criteria are met.

As noted under GRID OPERATION and SCREEN OPERATION, a protective spark gap should be connected from the control grid to ground and from the screen grid to ground. CPI Application Bulletin #17 titled FAULT PROTECTION contains considerable detail and is available on request. LOAD VSWR - The load VSWR should be monitored and the detected signal used to operate the interlock system to remove anode voltage within 20 milliseconds after a fault occurs. In the case of high stored energy in the load system, care must be taken to avoid excessive return energy from damaging the tube and associated circuit components.

MODE SUPPRESSION CONSIDERATIONS - High-performance high-power gridded tubes including the 4CM2500KG have natural circular resonance modes of oscillation which must be suppressed during initial testing of equipment. The short compact stem structure of EIMAC tubes provides easy access for mode suppression techniques. It is recommended that short pulse testing be used to detect this phenomenon and to evaluate the effectiveness of the suppression techniques used.

The 4CM2500KG has been found to exhibit circular mode oscillations in both L band and S band frequency ranges. These modes must be suppressed externally to prevent damage to the tube and to provide stable operation in the intended application. One technique which has worked to suppress these circular modes is using ferrite tiles. The ferrite tiles can be cemented (using General Electric RTV-102 or equivalent) to the conical and flat surfaces of the "screen deck" at the base of the tube. The size of the tiles can be up to approximately one inch square or rectangular and 0.1 to 0.3 inch thick. The ferrite must have properties such that it is not lossy at the fundamental frequency otherwise exces-

sive heating of the ferrite may occur. One source for the ferrite material is: National Magnetics Group, Inc. in Bethlehem, PA, USA. For further information contact CPI Microwave Power Products, EIMAC Operation.

In some instances, a compromise between tube efficiency and anode load impedance by way of modifying the output matching tuning and loading will prevent circular mode oscillations from occurring while a tube is delivering peak output. Adjustment of both the screen voltage and grid bias voltage while testing for circular mode oscillations is also predicated and fine adjustments in both parameters will often reduce or eliminate circular mode oscillations.

X-RADIATION HAZARD - High-vacuum tubes operating at voltages higher than 15 kilovolts produce progressively more dangerous X-ray radiation as the voltage is increased. This tube, operating at its rated voltages and currents, is a potential X-ray source. Only limited shielding is afforded by the tube envelope. Moreover, the X-radiation level may increase significantly with tube aging and gradual deterioration, due to leakage paths or emission characteristics as they are affected by the high voltage. X-ray shielding may be required on all sides of tubes operating at these voltages to provide adequate protection throughout the life of the tube. Periodic checks on the X-ray level should be made, and the tube should never be operated without required shielding in place. If there is any question as to the need for or the adequacy of shielding, an expert in this field should be contacted to perform an X-ray survey. In cases where shielding has been found to be required, operation of equipment with interlock switches "cheated" and cabinet doors open in order to be better able to locate an equipment malfunction can result in serious X-ray exposure.

RADIO-FREQUENCY RADIATION - Avoid exposure to strong rf field even at relatively low frequency. Absorption of rf energy by human tissue is dependent on frequency. OSHA (Occupational Safety and Health Administration) recommends that prolonged exposure to rf radiation should be limited to 10 milliwatts per square centimeter.

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INTERELECTRODE CAPACITANCE - The actual internal interelectrode capacitance of a tube is influenced by many variables in most applications, such as stray capacitance to the chassis from the tube terminals and associated wiring. To control the actual capacitance values within the tube, as the key component involved, the industry and military services use a standard test procedure described in Electronic Industries Association Standard RS-191. The test is performed on a cold tube, and in the case of the 4CM2500KG, with no special shielding. Other factors being equal, controlling internal tube capacitance in this way normally assures good interchangeability of tubes over a period of time. The capacitance values shown in the test specification or technical data are taken in accordance with Standard RS-191.

The equipment designer is cautioned to make allowance for the capacitance values, including tube-to-tube variation and strays, which will exist in any normal application. Measurements should be taken with mounting which represent approximate final layout if capacitance values are highly significant in the design.

SPECIAL APPLICATIONS - When it is desired to operate this tube under conditions different from those listed here, write to CPI Microwave Power Products, EIMAC Operation ATTN: Applications Engineering; 607 Hansen Way, Palo Alto, CA 94304 USA.

OPERATING HAZARDS

Proper use and safe operating practices with respect to power tubes are the responsibility of equipment manufacturers and users of such tubes. All persons who work with or are exposed to power tubes or equipment which utilizes such tubes must take precautions to protect themselves against possible serious bodily injury. Do not be careless around such products.

Operation of this tube may involve the following hazards, any one of which, in the absence of safe operating practices and precautions, could result in serious harm to personnel.

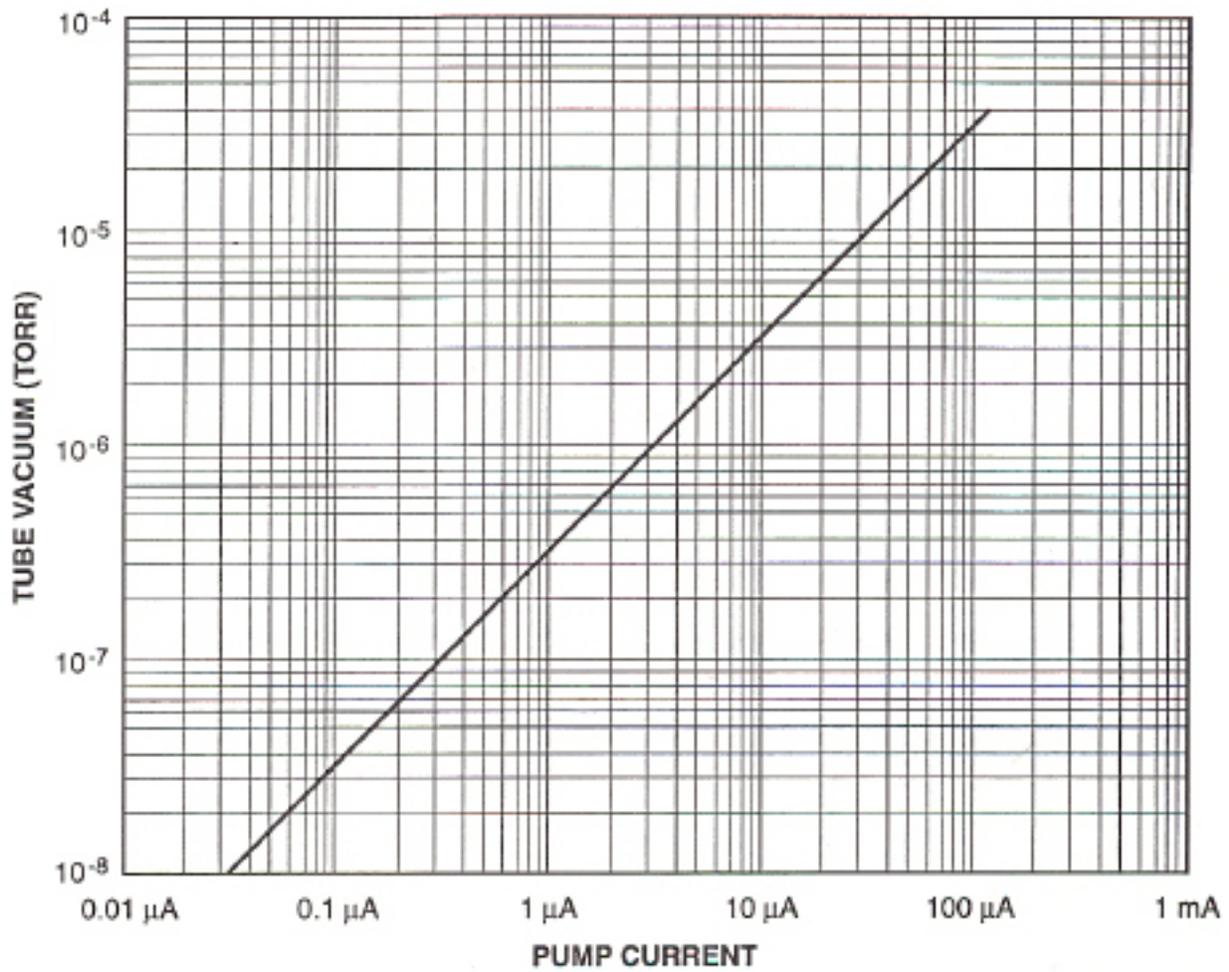
HIGH VOLTAGE – Normal operating voltages can be deadly. Remember the HIGH VOLTAGE CAN KILL.

LOW-VOLTAGE HIGH-CURRENT CIRCUITS - Personal jewelry, such as rings, should not be worn when working with filament contacts or connectors as a short circuit can produce very high current and melting, resulting in severe burns.

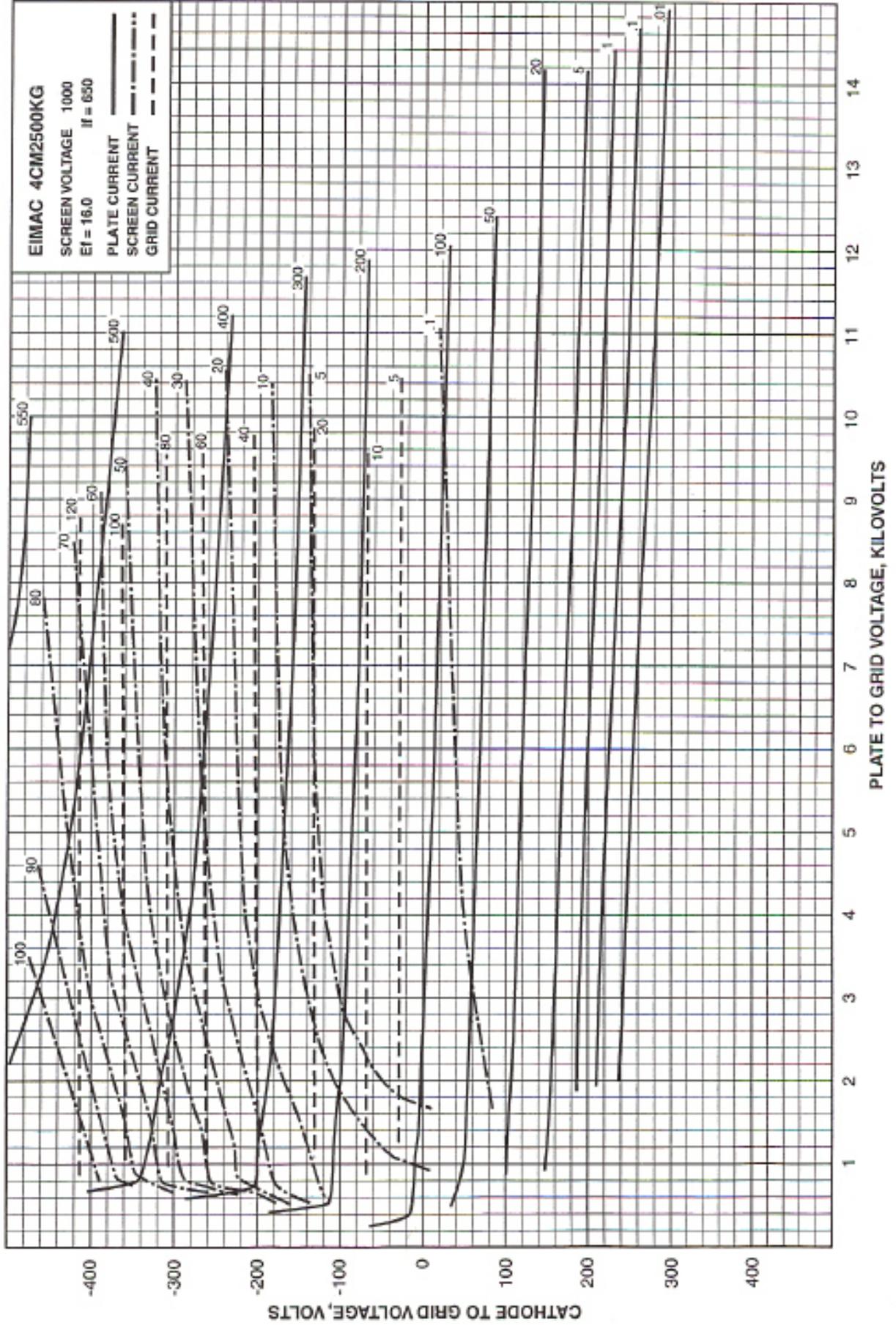
RF RADIATION – Exposure to strong rf fields should be avoided, even at relatively low frequencies. **CARDIAC PACEMAKERS MAY BE AFFECTED.**

HOT SURFACES – Surfaces of tubes can reach temperatures of several hundred °C and cause serious burns if touched for several minutes after all power is removed.

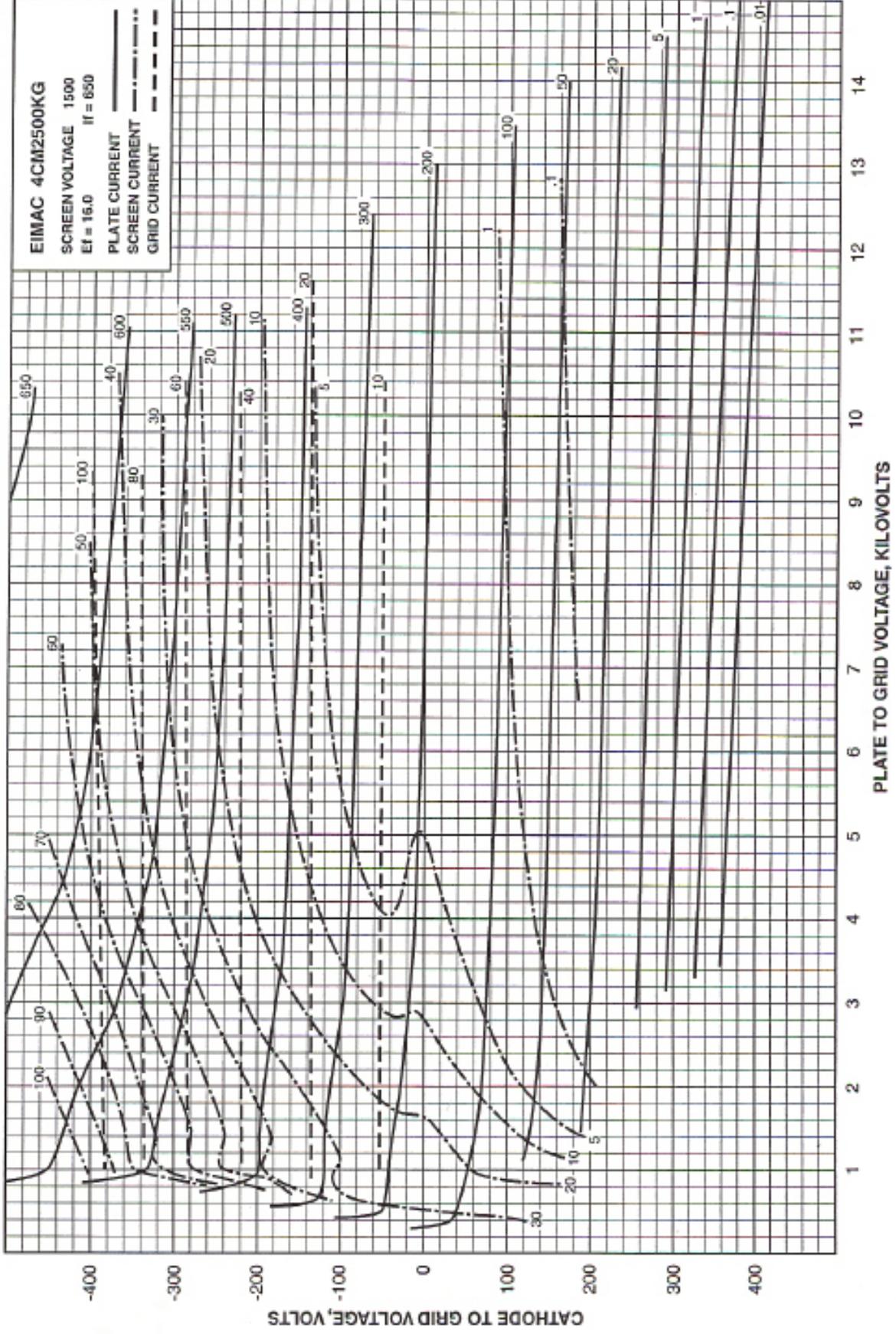
MATERIAL COMPLIANCE - This product and package conforms to the conditions and limitations specified in 49CFR 173.424 for radioactive material, excepted package-instruments or articles, UN2910. In addition, this product and package contains no beryllium oxide (BeO).



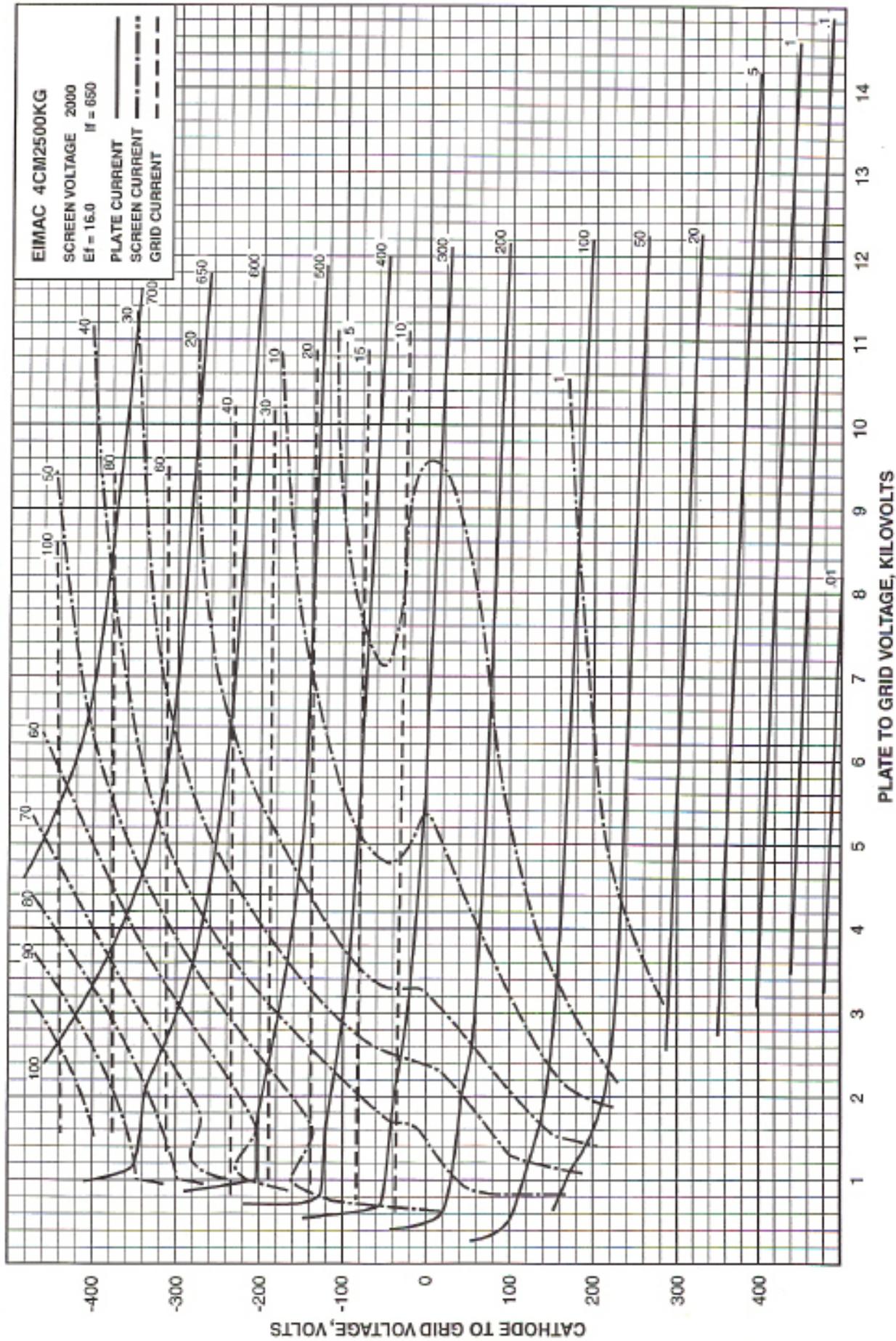
**GROUNDING GRID
CONSTANT CURRENT CHARACTERISTICS**



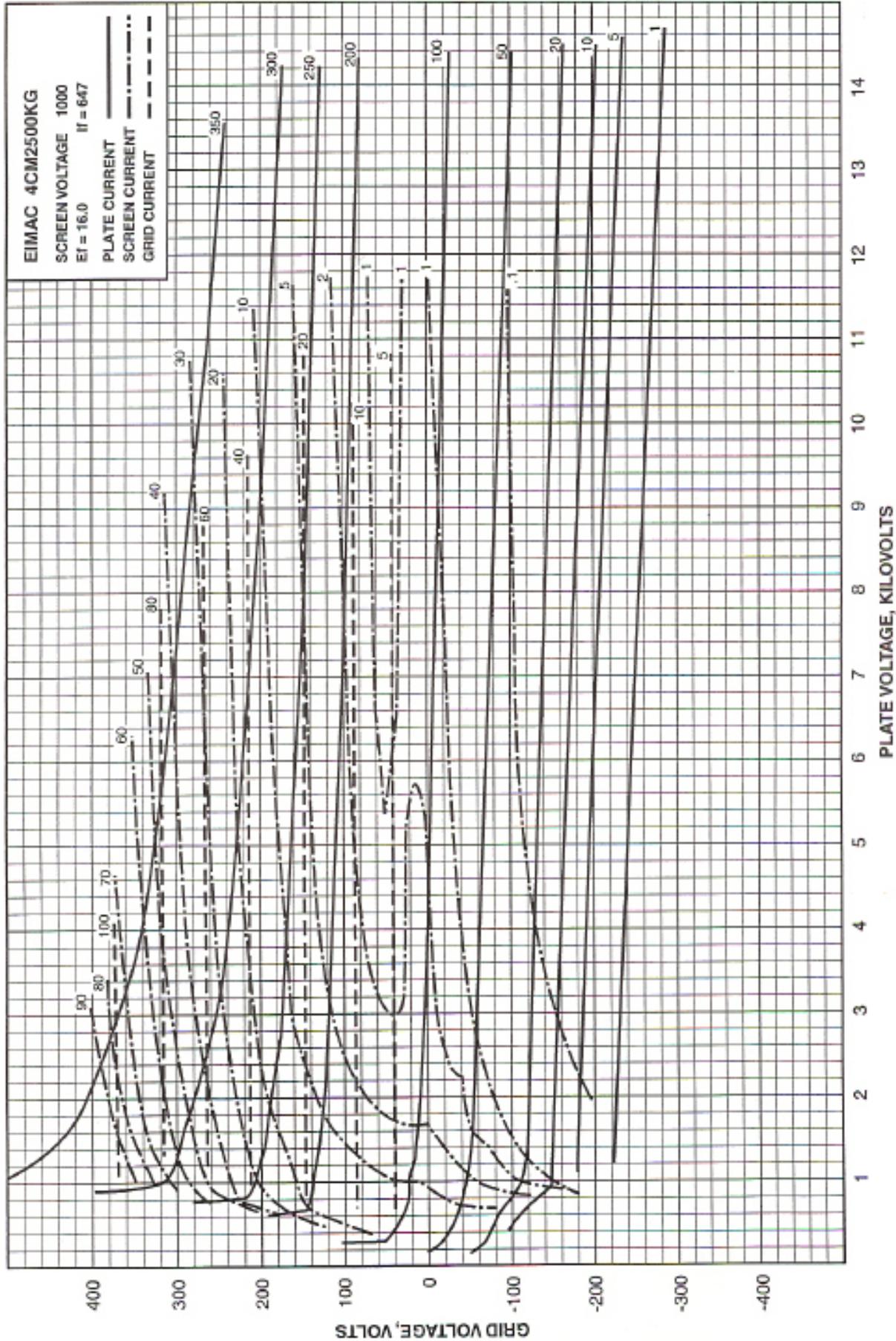
GROUNDED GRID CONSTANT CURRENT CHARACTERISTICS



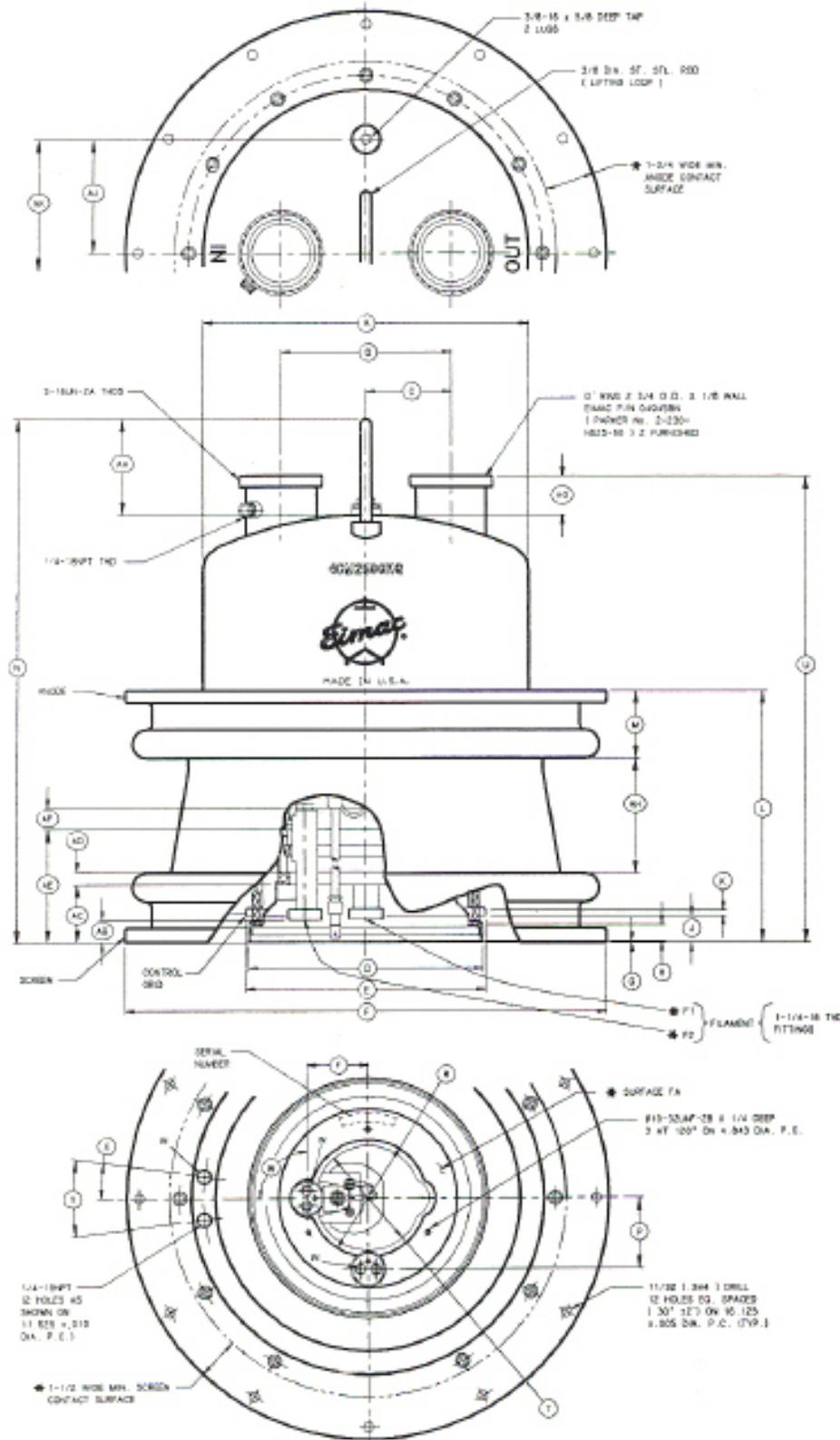
GROUNDING GRID
CONSTANT CURRENT CHARACTERISTICS



GROUNDED CATHODE
CONSTANT CURRENT CHARACTERISTICS



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DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	11.440	11.340		290.50	289.62	
B		6.000			152.40	
C		3.500			88.90	
D	8.235	8.285		209.17	209.93	
E	8.485	8.525		215.50	216.34	
F	16.970	17.030		431.04	432.50	
G		.625			.635	
H	.310			7.87		
J	.950	1.000		24.13	25.40	
K	.180			4.57		
L	8.705	8.900		220.98	226.06	
M		2.375			60.32	
N	18.500	18.750		469.90	476.25	
P		2.500			63.50	
R	4.113	4.137		104.47	105.08	
T	3.675	3.695		93.34	93.95	
U	16.250	16.500		412.73	419.10	
V		2.156			54.76	
W		90°				
X		7.5°				
Y		15°				
AA		3.675			93.60	
AB		.720			18.29	
AC	1.950	2.100		49.53	53.34	
AD	.450			11.43		
AE	3.580	3.680		90.42	93.47	
AF	.725			18.42		
AG		1.375			34.89	
AH		4.093			103.95	
AI		4.000			101.60	
AJ		8.000			203.20	