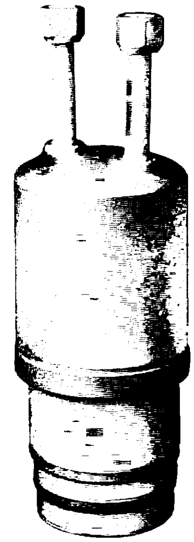
4CW30,000A
LIQUID COOLED POWER TETRODE



The EIMAC 4CW30,000A is a liquid and forced air cooled power tetrode for rf amplifier and pulse modulator service. It is recommended for radio frequency amplifier service through VHF where a liquid-cooled anode is required. Incorporating a special anode cooling jacket and a rugged thoriated tungsten mesh filament, this tube achieves a very low level of mechanically induced amplitude modulation of the plate current. Low rf losses in this structure permit operation at full ratings to 110 MHz and at reduced ratings to 225 MHz.

The 4CW30,000A is also recommended for pulse modulator or regulator service, where the hold-off rating is 28 kilovolts. 35 amperes of peak plate current may be obtained in pulse modulator service.

GENERAL CHARACTERISTICS[1]

ELECTRICAL

Filament: Thoriated Tungsten	
Voltage	10.0 ± 0.5 V
Current at 10.0 volts	140 A
Amplification Factor, average	
Grid to Screen	6.7
Direct Interelectrode Capacitance (cathode grounded)[2]	
Cin	190 pF
Cout	23.5 pF
Cgp	1.5 pF
Direct Interelectrode Capacitance (grid and screen grounded)[2]	
Cin	83 pF
Cout	24.5 pF
Cpk	0.2 pF
Maximum Frequency for Full Ratings (CW)	110 MHz

1. Characteristics and operating values are based on performance tests. These figures may change without notice as the result of additional data or product refinement. Varian EIMAC should be consulted before using this information for final equipment design.
2. Capacitance values are for a cold tube as measured in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

MECHANICAL

Maximum Overall Dimensions:	
Length	12.69 In; 32.23 cm
Diameter	4.63 In; 11.76 cm
Net Weight (approximate)	13.5 Lb; 6.1 kg
Operating Position	Axis Vertical, base up or down
Cooling	Water & Forced Air
Operating Temperature Maximum (Ceramic/Metal Seals and Envelope)	250°C
Base	Special, Coaxial
Recommended Air-System Sockets:	
Pulse, LF or HF Applications	EIMAC SK-300A
VHF applications	EIMAC SK-360
Recommended Screen Grid Bypass Capacitor Kit for the SK-360 Socket	EIMAC SK-355
Available Anode Connector Clip	EIMAC ACC-3

RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Class C Telegraphy or FM
(Key-Down Conditions)

ABSOLUTE MAXIMUM RATINGS;

DC PLATE VOLTAGE	12.5	KILOVOLTS
DC SCREEN VOLTAGE	2.0	KILOVOLTS
DC GRID VOLTAGE	-1.5	KILOVOLTS
DC PLATE CURRENT	5.0	AMPERES
PLATE DISSIPATION	30	KILOWATTS
SCREEN DISSIPATION	450	WATTS
GRID DISSIPATION	200	WATTS

* Approximate value

TYPICAL OPERATION (frequencies to 30 MHz)

Plate Voltage	7.5	9.0	kVdc
Screen Voltage	750	900	Vdc
Grid Voltage	-200	-250	Vdc
Plate Current	3.68	4.01	Adc
Screen Current *	208	222	mAdc
Grid Current *	91	88	mAdc
Peak rf Grid Voltage *	265	300	v
Calculated Driving Power	24.1	26.4	W
Plate Dissipation	5.84	7.93	kW
Plate Output Power *	21.8	28.2	kW
Load Impedance	1062	1136	Ohms

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DC GRID VOLTAGE	-1.5	KILOVOLTS
DC PLATE CURRENT	5.0	AMPERES
PLATE DISSIPATION	30	KILOWATTS
SCREEN DISSIPATION	450	WATTS
GRID DISSIPATION	200	WATTS

TYPICAL OPERATION (frequencies to 110 MHz)

Plate Voltage	9.0	10.0	12.0	kVdc
Screen Voltage	800	1000	1000	Vdc
Grid Voltage	-300	-460	-500	Vdc
Plate Current	4.15	4.65	3.54	Adc
Screen Current *	200	253	238	mAdc
Grid Current *	38	59	53	mAdc
Driving Power *	360	375	340	W
Useful Output Power * #	28.9	35.2	34.4	kW
Efficiency *	77.4	80.0	84.2	%
Gain *	19	18	20	dB

* Approximate value # Delivered to the load

AUDIO FREQUENCY POWER AMPLIFIER OR MODULATOR - GRID DRIVEN

Class AB1 (sinusoidal wave)

ABSOLUTE MAXIMUM RATINGS (per tube)

DC PLATE VOLTAGE	12.5	KILOVOLTS
DC SCREEN VOLTAGE	2.5	KILOVOLTS
DC GRID VOLTAGE	-1.5	KILOVOLTS
DC PLATE CURRENT	6.0	AMPERES
PLATE DISSIPATION	30	KILOWATTS
SCREEN DISSIPATION	450	WATTS
GRID DISSIPATION	200	WATTS

* Approximate value. ## Per Tube.

TYPICAL OPERATION (Two tubes in push-pull)

Plate Voltage	7.8	7.8	7.8	kVdc
Screen Voltage	500	750	1500	Vdc
Grid Voltage #	-70	-125	-250	Vdc
Zero-signal Plate Current ##	0.75	0.75	1.0	Adc
Maximum-signal Plate Current	3.4	5.2	9.2	Adc
Maximum-signal Screen Current *	90	220	600	mAdc
Peak Audio Freq.Grid Voltage *	65	115	200	v
Maximum-Signal Plate Dissipation ##	6.0	7.0	13.5	kW
Plate Output Power *	14.5	26.0	44.0	kW
Load Resistance (plate to plate)	6300	3500	1600	Ohms

\# Adjust for specified zero-signal plate current.

PULSE MODULATOR OR REGULATOR SERVICE

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	28	KILOVOLTS
DC SCREEN VOLTAGE	2.5	KILOVOLTS
DC GRID VOLTAGE	-1.5	KILOVOLTS
PEAK PLATE CURRENT	35	AMPERES
PLATE DISSIPATION	30	KILOWATTS
SCREEN DISSIPATION	450	WATTS
GRID DISSIPATION	200	WATTS
MAXIMUM PULSE DURATION	0.1	SECOND

Note: Operation at altitudes significantly above sea level may require the use of a protective atmosphere or a reduction in the plate voltage and screen voltage maximum values shown.

CAUTION: X-RADIATION HAZARD - See detailed X-Radiation Hazard application note.

TYPICAL OPERATION values are obtained by measurement or by calculation from published characteristic curves. To obtain the specified plate current at the specified bias, screen, and plate voltages, adjustment of the rf grid voltage is assumed. If this procedure is followed, there will be little variation in output power when the tube is replaced, even though there may be some variation in grid and screen currents. The grid and screen currents which occur when the desired plate current is obtained are incidental and vary tube to tube. These current variations cause no performance degradation providing the circuit maintains the correct voltage in the presence of the current variations.

RANGE VALUES FOR EQUIPMENT DESIGN

	MIN.	MAX.	
Filament Current, at 10.0 volts	135	145	A
Interelectrode Capacitances, cathode grounded [1]			
Cin	187.0	199.0	pF
Cout	21.5	25.5	pF
Cgp	---	2.0	pF
Interelectrode Capacitances, grid & screen grounded [1]			
Cin	84.0	91.0	pF
Cout	22.0	26.0	pF
Cpk	---	0.3	pF

1. Capacitance values are for a cold tube in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

APPLICATION

MECHANICAL

MOUNTING - The tube must be operated with its axis vertical. The base of the tube may be up or down at the option of the circuit designer.

STORAGE - If a tube is to be stored as a spare it should be kept in its original shipping carton, with the original packing material, to minimize the possibility of handling damage.

SOCKETS - The EIMAC air-system sockets SK-300A and SK-360 are designed to allow forced-air cooling of the concentric base terminals of the tube. The SK-300A is recommended for use through 30 MHz, while the SK-360 is recommended for applications in the VHF range. The SK-360 incorporates low-inductance filament bypassing in the form of three 5000 pF copper-clad Kapton® capacitors. A screen grid bypass capacitor kit, the SK-355, is also available for the SK-360, and includes eight 1000 pF 5000 DCWV capacitors (EIMAC P/N 050706), 16 mounting clips (EIMAC P/N 242859), and an assembly drawing (EIMAC P/N 243135).

ANODE COOLING - Anode cooling is normally accomplished by circulating water through the jacket. Insufficient flow will cause the anode temperature to rise to levels which will shorten tube life. Also, if the coolant lines become clogged for any reason enough steam pressure may be generated to rupture the water jacket and destroy the tube. The table lists the minimum cooling water requirements at various dissipation levels with a maximum inlet water temperature of 50°C. System pressure should not exceed 100 psi.

Anode Dissipation (kW)	Minimum Water Flow (gpm)	Approximate Pressure Drop (psi)
10	2.2	3.3
15	3.0	5.0
20	4.0	8.0
25	5.0	11.5
30	6.5	17.0

Cooling water must be well filtered (with effectiveness the equivalent of a 100-mesh screen) to eliminate any solid materials, to 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.

Tube life can be seriously compromised by cooling water condition. 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 can be continuously monitored in the reservoir by readily available instruments.

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.

Other coolants such as Ethylene Glycol, Freon® and various oils are useful where ionic problems associated with water are to be avoided. Compatibility with such substances should be verified prior to use.

Both anode and base cooling should be applied before or simultaneously with the application of electrode voltages, including the tube heater. Cooling should normally continue for a short period after removal of electrode voltages to allow the tube to cool down properly. An interlock system should be used to remove all voltages from the tube (including filament) in case cooling fails or becomes impaired.

BASE COOLING - Auxiliary forced-air cooling of the tube base is required to maintain the filament and grid seal temperatures at safe operating levels. An air flow of approximately 50 cfm at 50°C maximum at sea level should be directed through the EIMAC air-system socket, toward the filament and grid seal areas. Seal temperature is the final criteria of effective cooling, and temperature-sensitive paints are available to the equipment designer for testing before equipment design is finalized. EIMAC Application Bulletin #20 titled TEMPERATURE MEASUREMENTS WITH EIMAC POWER TUBES is available on request.

Base cooling air also maintains the temperature of the beryllium copper socket contact fingers at a safe level; if these fingers are allowed to reach 150°C for any significant period of time they can lose their temper, or springy characteristic. If this happens, poor contact can result; especially in the filament circuit this can lead to dangerous arcing and melting of the metal which is a part of the tube's vacuum envelope. Catastrophic loss of the tube could result.

ELECTRICAL

FILAMENT CONSTRUCTION - The 4CW30,000A has a mesh thoriated tungsten filament/cathode. The mesh filament is more rugged than the standard type, which results in very low noise-modulation of the electron stream, for those applications where this is a factor. The mesh filament/cathode is preferred over conventional hairpin construction for use in VHF applications. The tube should be protected from shock and vibration.

FILAMENT WARMUP - During turn-on the filament in-rush current should be limited to 300 amperes. A suitable step-start procedure can accomplish this, with full operating temperature reached in as little as four or five seconds.

This tube is designed for commercial service, with no more than one normal off/on filament cycle per day. If additional cycling is anticipated the user should contact the Application Engineering group at EIMAC for additional information.

With a new tube, or one which has been in storage for a period of time, operation with filament voltage only (and tube cooling) applied for a period of 30 to 60 minutes is recommended before full operation begins. This allows the active getter material mounted within the filament structure to adsorb any residual gas molecules which may have accumulated during storage. Once normal operation has been established a filament warmup of four to five seconds is normally sufficient.

FILAMENT OPERATION - At rated (nominal) filament voltage the peak emission capability of the tube is many times that needed for Class C amplifier service. Reducing filament voltage will lower the filament temperature, which will substantially increase life expectancy. The correct value of filament voltage should be determined for the particular application. It is recommended the tube be operated at full nominal voltage for an initial stabilization period of 100 to 200 hours before any action is taken to operate at reduced voltage. Voltage should gradually be reduced until there is a slight degradation in performance (such as power output or distortion). The voltage should then be increased a few tenths of a volt above the value where performance degradation was noted for operation. The operating point should be rechecked after 24 hours. Filament voltage should be closely regulated when voltage is to be reduced below nominal in this manner, to avoid any adverse influence by normal line voltage variations.

In pulse modulator or pulsed rf amplifier service the filament supply may require regulation to hold it to nominal rated filament voltage. Operation in excess of the nominal 10.0 volt level will allow greater peak current but with a compromise in useful overall tube life.

Filament voltage should be measured at the tube base or socket, using an accurate rms-responding meter. Periodically throughout the life of the tube the procedure outlined above for reduction of voltage should be repeated, with voltage reset as required, to assure best tube life.

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

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 effected 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-radiation 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 equipment X-ray survey.

In cases where shielding has been found to be required operation of high voltage equipment with interlock switches "cheated" and the cabinet doors open in order to more easily locate an equipment malfunction can result in serious X-ray exposure.

ELECTRODE DISSIPATION RATINGS - The maximum dissipation ratings must be respected to avoid damage to the tube. An exception is plate dissipation which may be permitted to rise above the rated maximum during brief periods, such as may occur during tuning of an rf amplifier.

In pulsed operation the actual electrode dissipation levels are dependent on the individual waveshapes encountered in the operating equipment. If pulse time-of-rise and time-of-fall are a significant percentage of pulse duration during pulse modulator or switch tube service, dissipation may be considerably higher than shown by calculation. This is the result of of significant plate current flow with high voltage drop across the tube during the time-of-rise and time-of-fall.

GRID OPERATION - The maximum control grid dissipation is 200 watts, determined approximately by the product of the dc grid current and the peak positive grid voltage. It is recommended that a protective spark-gap device should be connected between control grid and cathode to guard against excessive voltage.

SCREEN OPERATION - The maximum screen grid dissipation is 450 watts. With no ac applied to the screen grid, dissipation is simply the product of dc screen voltage and the dc screen current. With screen modulation, dissipation is dependent on rms screen voltage and rms screen current.

CW operation at VHF frequencies may add significantly to the total grid dissipation due to the ac charging current in the internal capacitance between the screen grid and anode. Operation at lower plate voltage and/or lower drive levels will reduce the dissipation.

Plate voltage, plate loading, or bias voltage must never be removed while filament and screen voltages are present, since screen dissipation ratings will be exceeded. A protective spark-gap device should be connected between the screen grid and the cathode to guard against excessive voltage.

FAULT PROTECTION - In addition to the normal plate over-current interlock, screen current interlock, and coolant interlock, the tube must be protected from internal damage caused by an internal plate arc which may occur at high plate voltage. A protective resistance should always be connected in series with each tube anode, to help absorb power supply stored energy if an internal arc should occur. An electronic crowbar, which will discharge power supply capacitors in a few microseconds after the start of an arc, is recommended. A maximum of 50 joules total energy may be permitted to be dissipated in an internal arc. The protection criteria for each electrode 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 the protection is adequate.

EIMAC Application Bulletin #17 "FAULT PROTECTION" is available on request.

RADIO-FREQUENCY RADIATION - Avoid exposure to strong rf fields even at relatively low frequency. Absorption of rf energy by human tissue is dependent on frequency. Under 300 MHz most of the energy will pass completely through the human body with little attenuation or heating affect. Public health agencies are concerned with the hazard even at these frequencies. OSHA (Occupational Safety and Health Administration) recommends that prolonged exposure to rf radiation should be limited to 10 milliwatts per square centimeter.

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, capacitance added by the socket used, stray capacitance between tube terminals, and wiring effects. 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. This requires the use of a special test fixture which shields all external tube leads or contacts from each other and eliminates any capacitance reading to "ground". The test is performed on a cold tube. The capacitance values shown in the technical data are taken in accordance with Standard RS-191. The equipment designer is therefore cautioned to make allowance for the actual capacitance values which will exist in the appliction. Measurements should be taken with mounting which represents approximate final layout if capacitance is highly significant in the design.

SPECIAL APPLICATIONS - When it is desired to operate this tube under conditions widely different from those listed here, write to Varian EIMAC; attn: Applications Engineering; 301 Industrial Way; San Carlos, CA 94070 U.S.A.

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.

The 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:

a. HOT WATER - Water used to cool tubes may reach scalding temperatures. Touching or rupture of the cooling system can cause serious burns.

b. 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.

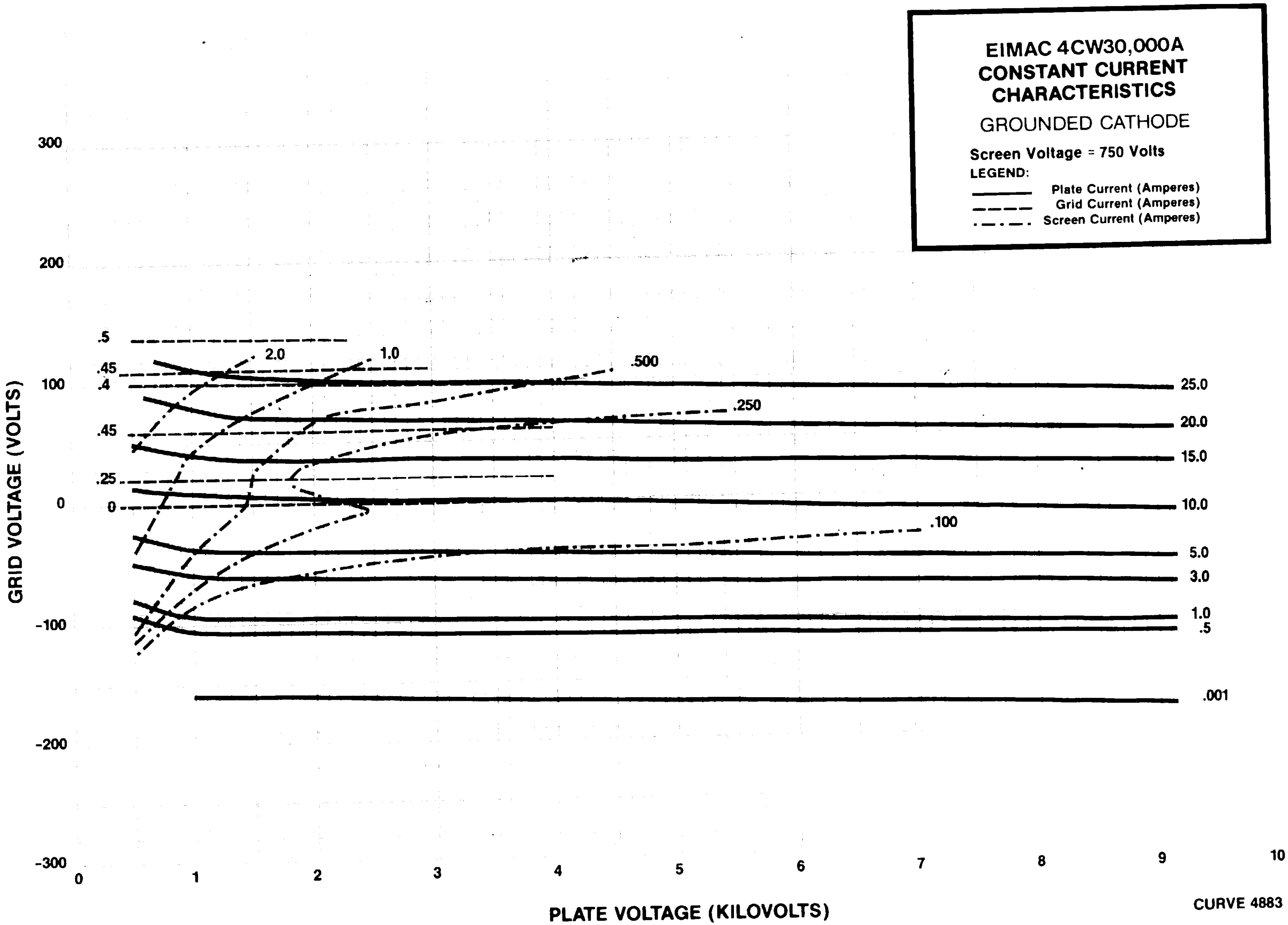
c. RF RADIATION - Exposure to strong rf fields should be avoided, even at relatively low frequencies. The dangers of rf radiation are more severe at UHF and microwave frequencies and can cause serious bodily and eye injuries. CARDIAC PACEMAKERS MAY BE AFFECTED.

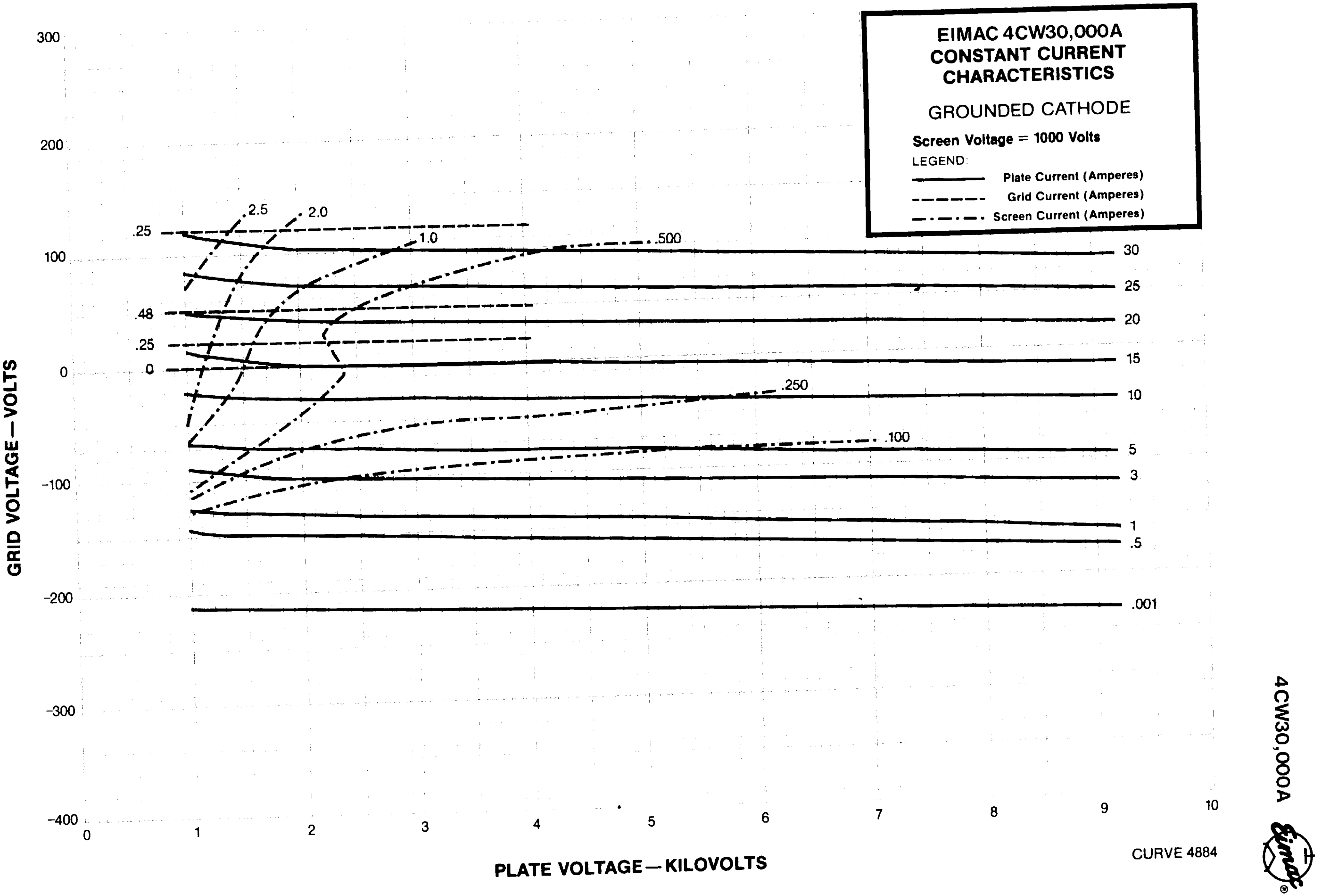
d. HIGH VOLTAGE - Normal operating voltages can be deadly. Remember that HIGH VOLTAGE CAN KILL.

e. X-RAY RADIATION - High-voltage tubes can produce dangerous and possibly fatal X-Rays. If shielding is provided equipment should never be operated without all such shielding in place.

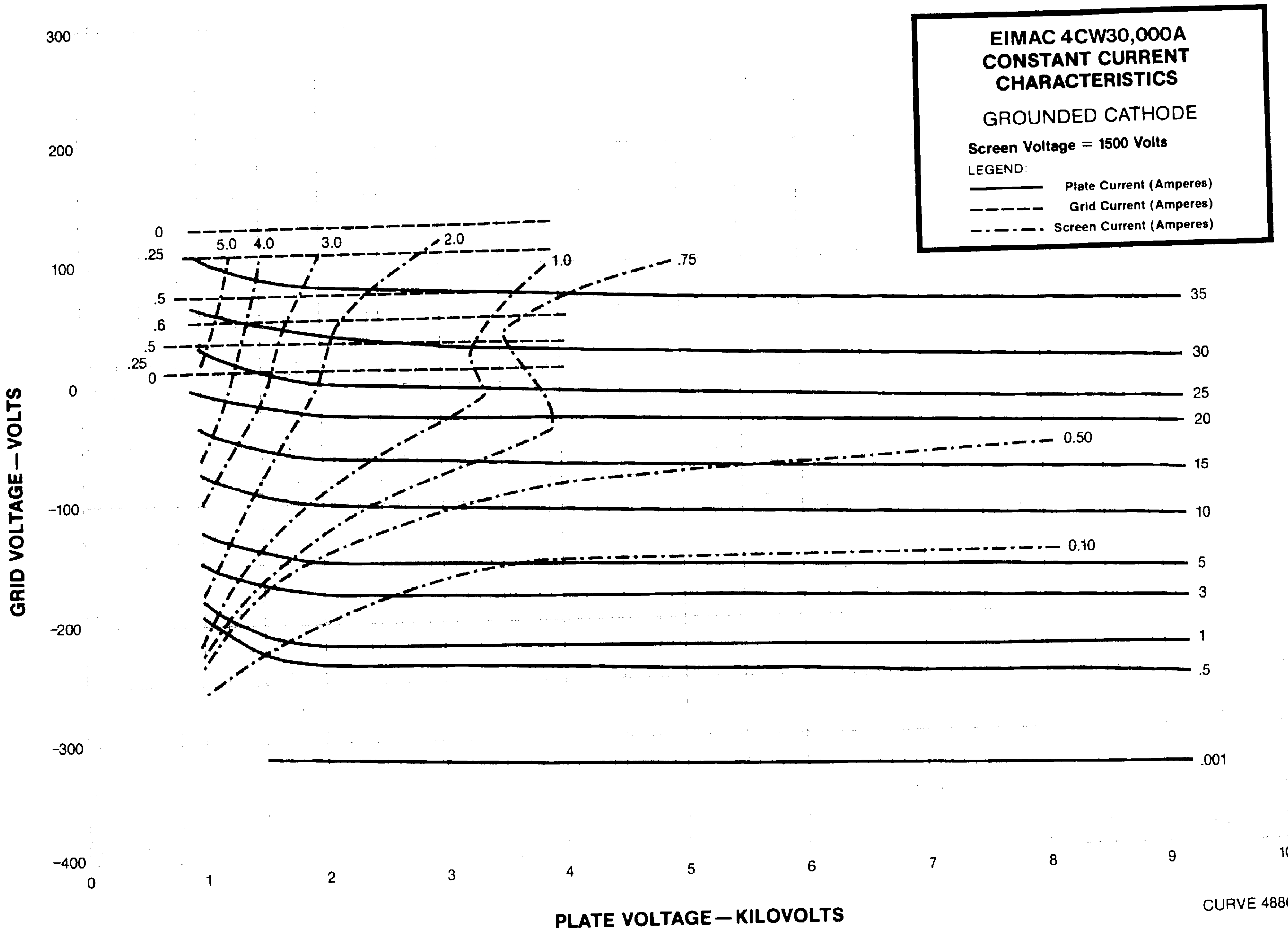
f. HOT SURFACES - Surfaces of tubes can reach temperatures of several hundred °C and cause serious burns if touched for several minutes after all power is removed.

Please review the detailed operating hazards sheet enclosed with each tube, or request a copy from: Varian EIMAC, Power Grid Application Engineering, 301 Industrial Way, San Carlos CA 94070.


EIMAC 4CW30,000A
CONSTANT CURRENT
CHARACTERISTICS
GROUNDED CATHODE
Screen Voltage = 750 Volts
LEGEND:
Plate Current (Amperes)
Grid Current (Amperes)
Screen Current (Amperes)
GRID VOLTAGE (VOLTS)
300
200
100
0
-100
-200
-300
PLATE VOLTAGE (KILOVOLTS)
0
1
2
3
4
5
6
7
8
9
10
.5
.45
.4
.45
.25
0
2.0
1.0
.500
.250
.100
25.0
20.0
15.0
10.0
5.0
3.0
1.0
.5
.001
CURVE 4883



EIMAC 4CW30,000A
CONSTANT CURRENT
CHARACTERISTICS
GROUNDED CATHODE
Screen Voltage = 1000 Volts
LEGEND:
Plate Current (Amperes)
Grid Current (Amperes)
Screen Current (Amperes)
GRID VOLTAGE—VOLTS
300
200
100
0
-100
-200
-300
-400
PLATE VOLTAGE—KILOVOLTS
0
1
2
3
4
5
6
7
8
9
10
.25
.48
.25
0
2.5
2.0
1.0
.500
.250
.100
30
25
20
15
10
5
3
1
.5
.001
CURVE 4884
4CW30,000A


EIMAC 4CW30,000A
CONSTANT CURRENT CHARACTERISTICS
GROUNDED CATHODE
Screen Voltage = 1500 Volts
LEGEND:
Plate Current (Amperes)
Grid Current (Amperes)
Screen Current (Amperes)
GRID VOLTAGE — VOLTS
PLATE VOLTAGE — KILOVOLTS
300
200
100
0
-100
-200
-300
-400
0
1
2
3
4
5
6
7
8
9
10
35
30
25
20
15
10
5
3
1
.5
.001
0
.25
.5
.6
.5
.25
0
5.0
4.0
3.0
2.0
1.0
.75
0.50
0.10
CURVE 4886

DIMENSIONAL DATA						
	INCHES			MILLIMETERS		
DIM	MIN	MAX	REF	MIN	MAX	REF
A	4.570	4.630		116.08	117.60	
B	2.625	2.875		66.68	73.03	
C	.600	.760		15.24	19.30	
D	1.896	1.936		48.16	49.17	
E	3.133	3.173		79.58	80.59	
F	3.792	3.832		96.32	97.33	
G	3.980	4.020		101.09	102.11	
H	.188			4.78		
J	.188			4.78		
K	.188			4.78		
P	9.065	9.565		230.25	242.95	
T	2.875	3.125		73.03	79.38	
U		4.750			120.65	
V	3.625	3.675		92.08	93.35	

NOTES:

1. REF DIMENSIONS ARE FOR INFO ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES.
2. DIMENSIONS IN [ ] ARE MILLIMETERS.
3. (*) CONTACT SURFACE.
4. OPTIMUM FILAMENT & GRID CONNECTOR HEIGHTS FOR SOCKET DESIGN PURPOSES.
5. LABEL IN RED INK ON COOLER TOP AS SHOWN.