TECHNICAL DATA

9009 (X-2062K) WATER COOLED POWER TETRODE

The 9009/X2062K is a ceramic/metal water-cooled power tetrode intended for use as a pulse modulator or in power conditioning regulator service.

The tube is rated for 150 kVdc holdoff in a protective atmosphere, with up to 90 amperes pulse anode current during conduction and a one megawatt average anode dissipation rating.

The tube is supplied with an integral VACION® pump for monitoring and maintenance of the tube vacuum.

GENERAL CHARACTERISTICS [1]

ELECTRICAL

Filament: Thoriated Tungsten	
Voltage	12.0 ± 0.6 V
Current, @ 12.0 volts	660 A
Amplification Factor (average)	
Grid to Screen	4.5
Direct Interelectrode Capacitance (grounded cathode) [2]	
Cin	770 pF
Cout	50 pF
Cgp	3 pF

1 Characteristics and operating values 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 measured with no special shielding.

MECHANICAL

Operating Position	Vertical, Base up or Down
Net Weight	175 lb; 80 kg
Maximum Overall Dimensions:	
Length	31.0 in; 79 cm
Diameter	17.03 in; 43.3 cm
Maximum Operating Temperature, Ceramic/Metal Seals	200 °C
Base Configuration	Special
Cooling	Liquid
Anode Water Connectors (2-inch Male NPT)	
Inlet	EIMAC SK-2322
Outlet	EIMAC SK-2322
Filament Connectors (2 required)	EIMAC SK-1711
Grid Connector	EIMAC SK-1712
Recommended High Voltage Protective Atmosphere Hood	EIMAC SK-2306

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PULSE MODULATOR OR REGULATOR SERVICE

ABSOLUTE MAXIMUM RATINGS (See Notes 1 and 2)

DC PLATE VOLTAGE	150	KILOVOLTS
DC SCREEN VOLTAGE	2500	VOLTS
PEAK PLATE CURRENT	90	AMPERES
PLATE DISSIPATION	1000	KILOWATTS
SCREEN DISSIPATION	3500	WATTS
GRID DISSIPATION	1500	WATTS
PULSE LENGTH	INFINITE	

The following guide should be used to limit plate energy for various pulse lengths (Max.duty = 0.25):

Pulse Length	Limit Plate Energy to:
0 - 10 uSec	13 joules/uSec
10 - 100 uSec	11 joules/uSec
100 - 1000 uSec	9 joules/uSec
1 - 10 mSec	7 joules/uSec
10 - 100 mSec	3 joules/uSec
over 100 mSec	1000 kW CW ratings apply (i.e. 1 joule/us)

TYPICAL OPERATION:

Plate Supply Voltage	120	kVdc
Plate Voltage During Conduction	3.0	kVdc
Screen Voltage	1500	Vdc
Grid Voltage	-900	Vdc
Plate Current During Pulse	50	a
Screen Current During Pulse *	2	a
Grid Current During Pulse *	0	a
Peak Power to the Load	5800	kw
Peak Plate Dissipation	200	kw

* Approximate

NOTES:

1. For operation above Eb = 60 kVdc the use of a protective atmosphere, such as SF6 or equivalent, is required between the screen and anode terminals. The EIMAC SK-2306 is recommended.
2. The 9009/X2062K has anode current capabilities in excess of 150 amperes for short pulses. See paragraph concerning special applications.

APPLICATION

MECHANICAL

INITIAL UNPACKING - To insure the safety of the tube, the following unpacking instructions should be followed:

1. The shipping crate is opened by removing the 4 hex-head bolts just above the carrying handles
2. Attach the lifting hoist to the lifting loop and raise slightly to support the weight of the tube.
3. Remove the 8 bolts securing the mounting brackets to the corner flanges.
4. Lift the tube and place on blocks or on a stand so that its weight is supported by the lower flange. MAKE SURE THAT THE DELICATE VACION® PUMP PROTRUDING FROM THE BASE OF THE TUBE IS NOT DAMAGED AT THIS STEP.
5. Remove the mounting brackets and the shipping ring from the tube by removing six 5/16-18 hex bolts. Again, USE CARE NOT TO DAMAGE THE VACION® PUMP.
6. Install the supplied six flat-head machine scews in the cooler assembly corona ring and torque to 12 ft-lbs.

MOUNTING - The tube must be mounted vertically, anode up or down. The tube should be supported by the screen flange when mounted for anode-up operation, but should be supported by the anode flange for anode-down operation.

COOLING - High velocity water flow is required to maintain high thermal efficiency. 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 the 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.

The table lists minimum cooling water requirements at various plate dissipation levels. Cooling water requirements are based on the larger of either average plate dissipation or energy per pulse. At 750 kw (peak) anode dissipation and pulse duration of one second or longer anode cooling water boiling will occur at 130 gpm.

Avg. Plate Diss. (kW)	Energy Per Pulse (kilojoules)	Water Flow (gpm)	Approx. Press. Drop (psig)
Fil.only	---	10	1
100	0 to 150	55	10
200	150 to 250	85	15
300	250 to 800	105	30
1000	800 to 1200	175	50

The filament supports are water cooled. Approximately 0.5 gpm must circulate through each of the filament connectors with a pressure drop of approximately 20 psi. Filament connector assemblies SK-1711 provide electrical and water connections. Two sets of SK-1711 are required. It is recommended the water cooled control grid connector, SK-1712, be used. Water flow of approximately 0.5 gpm should circulate through the grid connector. The pressure drop across the grid connector is low, and a convenient way to make water connection is to series connect the grid cooling water with the outer filament cooling water path from a constant pressure source.

Maximimum water system pressure should not exceed:

anode & control grid connectors: 100 psig test, 80 psig operating.

filament connectors: 80 psig test, 60 psig operating.

All tube cooling should be applied before or simultaneously with the application of electrode voltages, including filament voltage, and should normally be continued for a minimum of 60 seconds after all voltages are removed to allow for tube cooldown.

The equipment designer should include interlock circuitry so that any interuption or significant decrease in water flow in any of the cooling lines will cause equipment shutdown before overheating and possible tube damage can result.

Care should be taken to assure that cooling water is not at too low a temperature when the tube is used in a high-humidity ambient in order to prevent condensation which could lead to external electrical breakdown of the tube or its protective atmosphere hood.

ELECTRICAL

FILAMENT OPERATION - Filament voltage should be measured at the tube base with an accurate rms-responding meter. Voltage should normally be maintained as close to the nominal value as possible to assure adequate emission to meet the pulse current demands encountered in the normal service for which this tube is rated.

During turn-on filament inrush current must be limited to 1300 amperes.

ABSOLUTE MAXIMUM RATINGS - The 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 that the absolute values will never be exceeded under any usual conditions of supply voltage variation in the equipment itself. It does not necessarily follow that combinations of absolute maximum ratings can be attained simultaneously.

GRID OPERATION - The maximum control grid dissipation is 1500 watts, determined approximately by the product of the dc grid current and the peak positive grid voltage. A protective spark-gap device should be connected between the control grid and the cathode to guard against excessive voltage.

SCREEN GRID OPERATION - The maximum screen grid dissipation is 3500 watts. Average screen dissipation is simply the product of dc screen voltage and the dc screen current. Screen dissipation during the pulse is the product of pulse screen current and the dc screen voltage. 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.

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 be protected. To maintain high cooling efficiency the anode water flow must be sufficient to insure turbulent flow. EIMAC has determined that a minimum flow of 35 gpm (130 lpm) is required even at low levels of anode dissipation.

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. An electronic crowbar, which will discharge power supply capacitors in a few microseconds after the start of an arc, is recommended. 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 titled FAULT PROTECTION contains considerable detail, and is available on request.

VACION® PUMP OPERATION - The tube is supplied with an ion pump and magnet, mounted on the filament structure at the base (stem). A power supply (Varian Part #921-0015) and an 8-foot cable (Varian Part #924-0020) are required for operation. The primary function of this device is to allow monitoring of the condition of the tube vacuum, as shown by an pump current meter.
With an operational tube it is recommended the VACION® 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 current 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 pump current rises again it should be considered as indicating a circuit problem such that some tube element may be over-dissipating and outgassing.
Cold thoriated tungsten is a good getter of hydrogen which is released when the filament is heated. It is, therefore, normal to see a surge in the pump current when the filament is first turned on, particularly if the tube has been in storage. Normally the pump current will stabilize to 10 microamperes or less within 20 minutes.
In the case of a spare tube (non-operational) 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 better.
Figure 1 shows the relationship between tube vacuum and the pump 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 EIMAC and review the case details with an Applications Engineering specialist.

HIGH VOLTAGE - Normal operating voltages used with this tube are deadly, and the equipment must be designed properly and operating precautions must be followed. Design all equipment so that no one can come in contact with high voltages. All 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 bypassed or "cheated" 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-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 equipment X-ray survey.

Where shielding has been found to be required operation of high voltage 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.

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 as described in Electronic Industries Association Standard RS-191. This eliminates any capacitance reading to "ground". The test is performed on a cold tube. 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 technical data are taken in accordance with Standard RS-191 except that no specially shielded fixture is used.

The equipment designer is therefore cautioned to make allowance for the actual capacitance values which will exist in the application. Measurements should be taken with the mounting which represents approximate final layout if capacitance values are 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. HIGH VOLTAGE - Normal operating voltages can be deadly. Always remember HIGH VOLTAGE CAN KILL.

b. X-RADIATION - High voltage tubes can produce dangerous and possibly fatal X-Rays.

c. 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.

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

e. 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 Tube Division, 301 Industrial Way, San Carlos CA 94070.

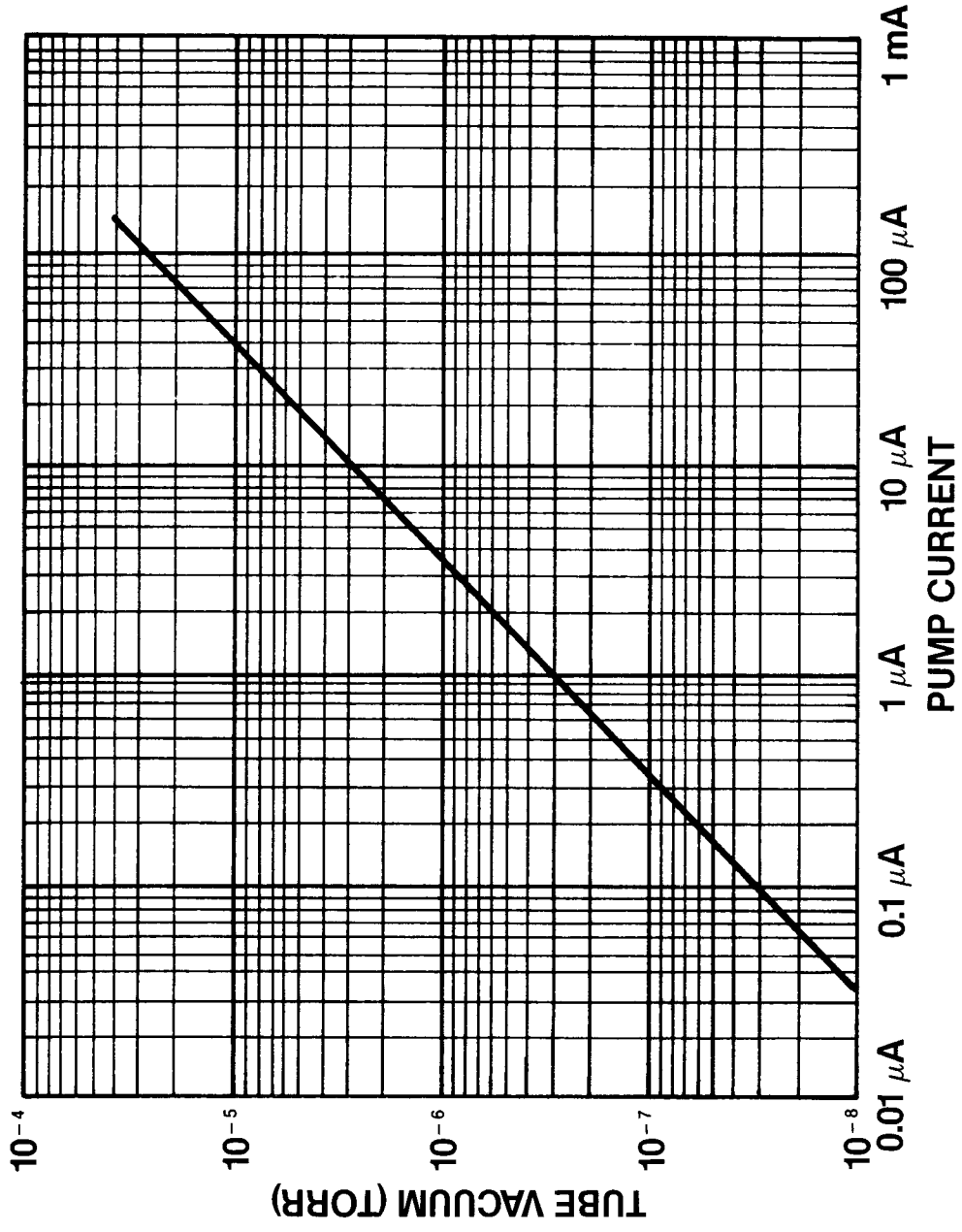
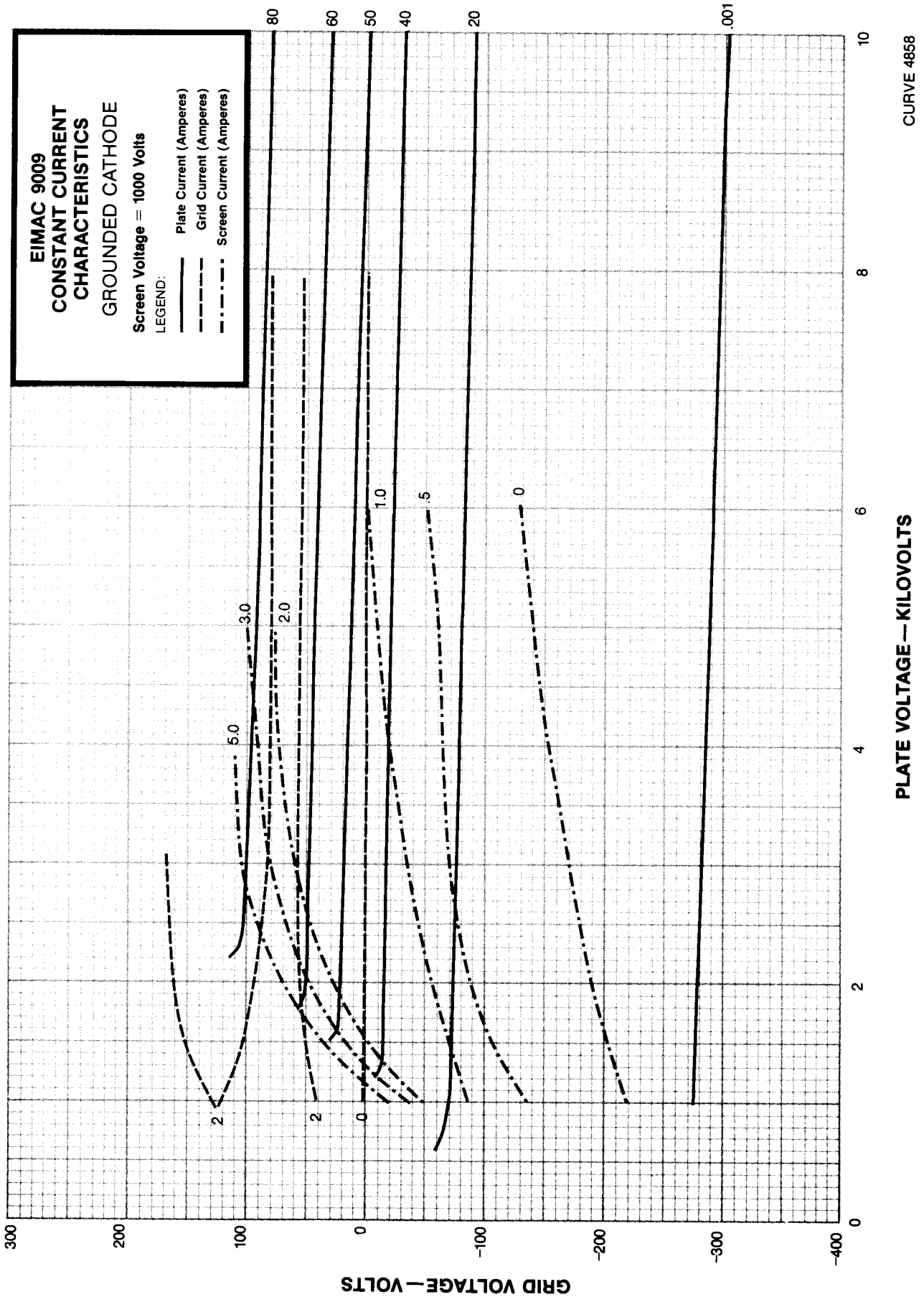
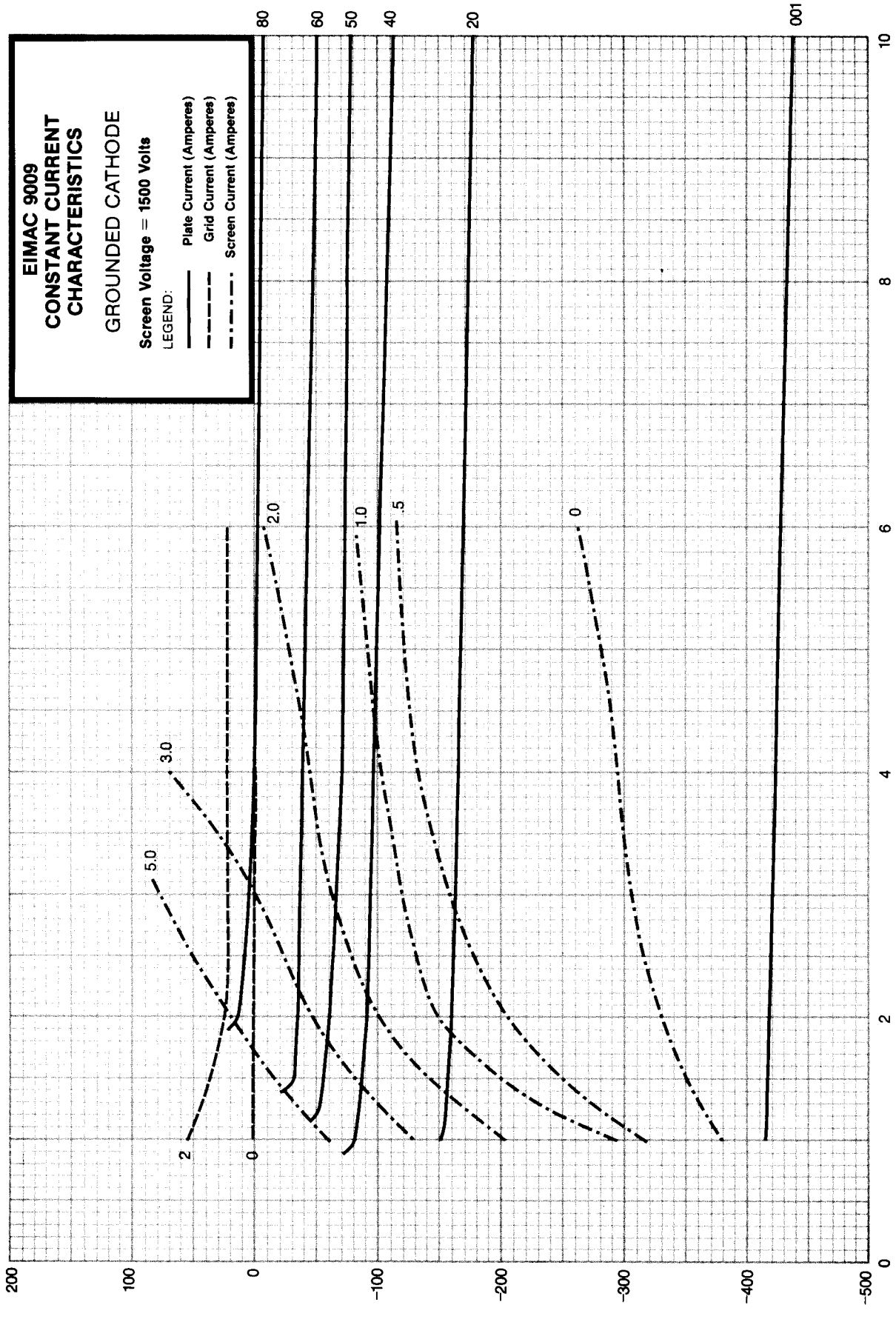
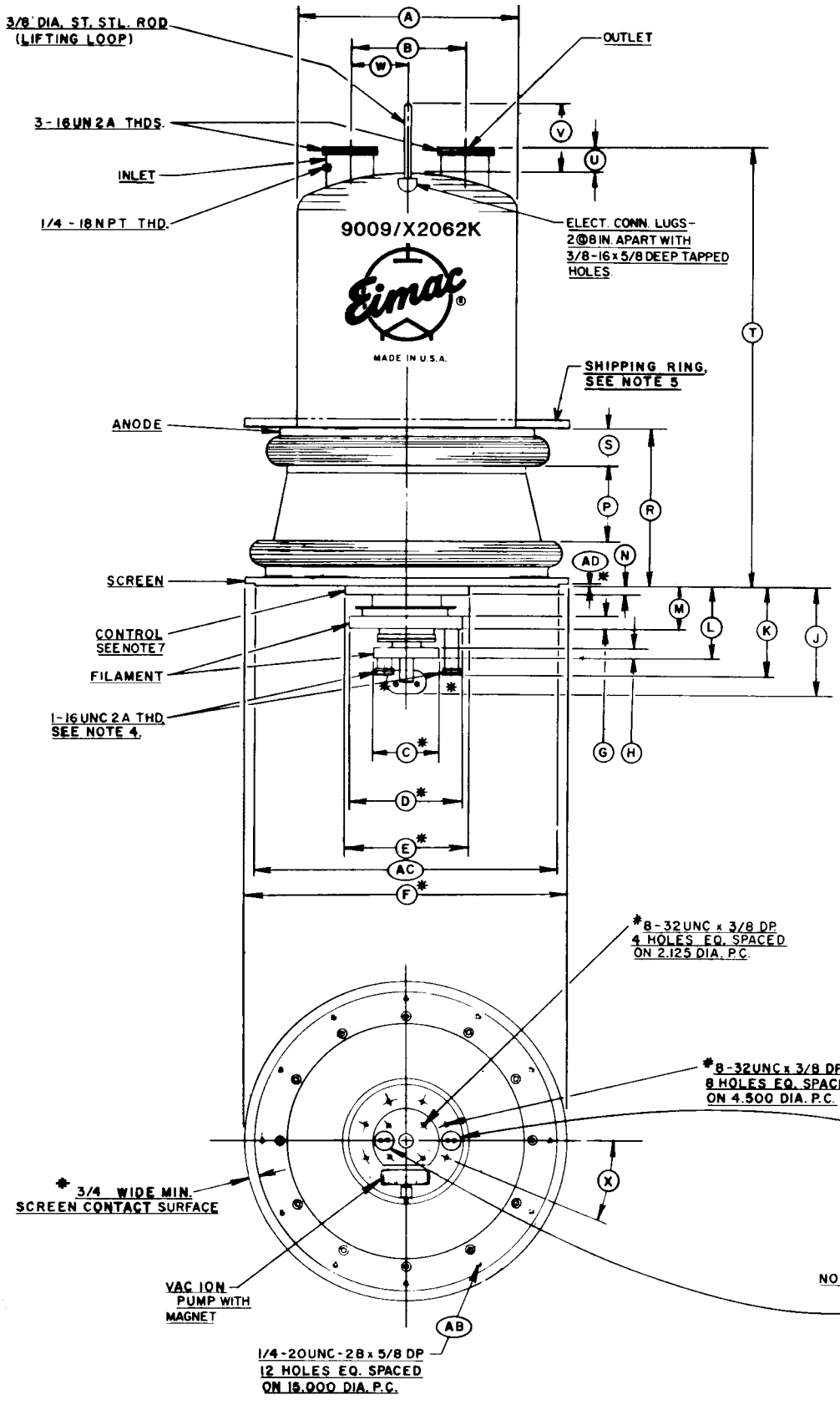


Figure 1 - Tube Vacuum VS Ion Current Reading


EIMAC 9009
CONSTANT CURRENT
CHARACTERISTICS
GROUNDED CATHODE
Screen Voltage = 1000 Volts
LEGEND:
Plate Current (Amperes)
Grid Current (Amperes)
Screen Current (Amperes)
80
60
50
40
20
.001
5.0
3.0
2.0
2
2
0
1.0
.5
0
300
200
100
0
-100
-200
-300
-400
0
2
4
6
8
10
GRID VOLTAGE—VOLTS
PLATE VOLTAGE—KILOVOLTS
CURVE 4858


EIMAC 9009
CONSTANT CURRENT
CHARACTERISTICS
GROUNDED CATHODE
Screen Voltage = 1500 Volts
LEGEND:
Plate Current (Amperes)
Grid Current (Amperes)
Screen Current (Amperes)
80
60
50
40
20
001
5.0
3.0
2
2.0
1.0
.5
0
0
200
100
0
-100
-200
-300
-400
-500
0
2
4
6
8
10
GRID VOLTAGE—VOLTS
PLATE VOLTAGE—KILOVOLTS

CURVE 4859



DIMENSIONAL DATA						
	INCHES			MILLIMETERS		
DIM	MIN	MAX	REF	MIN.	MAX	REF
A	11.440	11.560		290.6	293.6	
B		6.000				
C	3.437	3.562		87.3	90.5	
D	5.937	6.062		150.8	152.4	
E	6.437	6.562		163.5	167	
F	16.970	17.030		431	433	
G	.593			15.1		
H	.593			15.1		
J			4.871			123.7
K	4.494	4.624		114.1	117.4	
L	3.594	3.718		91.3	94.4	
M	1.999	2.119		50.8	53.8	
N						
P						
R	8.400	8.600		213.4	218.4	
S			2.062			52.4
T			23.165			58.8
U			1.375			34.9
V			3.575			90.8
W			3.000			76
X			22-1/2°			
Y			.219			5.6
Z			.438			11.1
AA			.261			5.9
AB	SEE NOTE 3					
AC	15.718	15.781		399.2	400.8	
AD	.046	.078		1.17	1.98	

NOTES:

1. REF. DIMENSIONS ARE FOR INFO ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES.
2. * CONTACT SURFACES
3. AXIS OF AA HOLES TO BE ALIGNED WITH AB HOLES WITHIN 15°
4. A TUBE OF ANTI-SEIZE THREAD LUBRICANT IS PROVIDED WITH TUBE TO PREVENT GALLING OF FILAMENT CONNECTOR THREADS, SEE INSTR. SHEET E14-11 ATTACHED TO TUBE.
5. BEFORE UNPACKING TUBE, REFER TO INSTR. SHEET E14-61 ATTACHED TO TUBE.
6. MATE WITH EIMAC CONNECTOR SK1710
7. MATE WITH EIMAC CONNECTOR SK1712.