MULTIPHASE-COOLED POWER TETRODE
4CM500,000G

The Eimac 4CM500,000G is a ceramic/metal high power tetrode designed to be used as an exact replacement for the Thales TH558. This tube has a thoriated-tungsten mesh filament and it uses pyrolytic graphite grids which provide high dissipation capability combined with low secondary emission characteristics. The multiphase-cooled anode is rated for 500 kilowatts steady state.

CHARACTERISTICS[1]

ELECTRICAL

Filament: Thoriated Tungsten Mesh	
Voltage (See Filament Operation Paragraph)	23.0 V
Current at 23.0 Volts	500 A
Amplification Factor (average grid to screen)	4.4
Maximum Frequency for CW	30 MHz
Direct Interelectrode Capacitances[2]	
Cg1-k	520 pF
Cg2-k	48 pF
Cp-k	0.9 pF
Cg1-g2	780 pF
Cg1-p	6.3 pF
Cg2-P	115 pF

MECHANICAL:

Overall Dimensions:	
Length	25.7 in; 65.3 cm
Diameter (anode mtg. flange)	12.6 in; 32.1 cm
Net Weight	134 lb. 60.78 kg
Gross Weight	336 lb. 152.4 kg
Operating Postition	Vertical, Base Down
Maximum Operating Temperature:	
Ceramic/Metal Seals & Envelope	200° C
Anode Cooling	Multiphase Water
Base Cooling	Forced Air

[1] Characteristics and operating values are based upon performance tests. These figures may change without notice as the result of additional data or product refinement. CPI MPP/Eimac Operation 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.

RANGE VALUES FOR EQUIPMENT DESIGN	Min.	Max.	
Filament Current @ 23 Volts	480	560	A

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.

ISO 9001

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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ANODE MODULATED AMPLIFIER SERVICE
Class C Telephony
Control and Screen Grids also modulated

ABSOLUTE MAXIMUM RATINGS:

DC ANODE VOLTAGE	15.0	kV
DC SCREEN VOLTAGE	1250	V
DC GRID VOLTAGE	-800	V
PEAK ANODE CURRENT	500	A
DC ANODE CURRENT	65	A
ANODE DISSIPATION	350	kW[2]
SCREEN DISSIPATION	8000	W[3]
GRID DISSIPATION	3000	W[3]

TYPICAL OPERATION[5] (Frequencies below 30 MHz):
(Carrier Conditions)

DC ANODE VOLTAGE	12.5	kV
DC SCREEN VOLTAGE	1000	V
DC GRID VOLTAGE	-600	V
DC ANODE CURRENT	54	A
DC SCREEN CURRENT[4]	5.0	A
DC GRID CURRENT	5.0	A
PEAK AF SCREEN VOLTAGE[1]	706	V
CALCULATED DRIVING POWER[4]	3.0	kW
ANODE DISSIPATION	125	kW
ANODE OUTPUT POWER[4]	550	kW
RESONANT ANODE LOAD IMPEDANCE	230	Ohms

[1] At 100% Modulation

[2] Corresponds to 500 kW at 100% sine-wave modulation

[3] Average values, with or without modulation

[4] Approximate values

[5] Calculated values, not including circuit losses

NOTE: TYPICAL OPERATION data are obtained by actual measurement or by calculation from published characteristic curves. To obtain the anode current shown at the specified bias, screen and anode voltages, adjustment of 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 anode current is obtained are incidental and vary from tube to tube. These current variations should cause no performance degradation providing the circuit maintains the correct voltages in the presence of the current variations.

APPLICATION

MECHANICAL

HANDLING – Upon arrival, the tube should be inspected for shipping damage; when removed from the crate it should be handled with considerable care.

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 can be attached 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 (approx. 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. Cooling water should also be purged from the tube prior to shipment. The original shipping crate with the shock mounts and hardware should be retained in a dry place for future use.

MOUNTING – The 4CM500,000G must be mounted with its major axis vertical and the anode cooler in the upright position.

SOCKETING – The tube should be properly centered as it is inserted into the socket and pushed down completely to assure good electrical contact and to allow proper forced-air cooling of the tube base and socket contact fingers.

ANODE COOLING – Anode cooling is accomplished by circulating high velocity water through the water jacket. The inlet and outlet connections are clearly marked on top of the anode cooler and it is important they be connected only as indicated.

Multiphase cooling provides efficient anode heat removal and allows extra capacity for temporary overloads. Tube life can be seriously compromised by poor water quality. Contaminated water will leave deposits on the inside of the water jacket and cooling passages, causing localized anode heating and eventual tube failure. To minimize electrolysis and power loss, water resistivity at 25°C should always be 0.5 megohm per cubic centimeter or higher. Water resistivity can be continuously monitored in the reservoir using readily available instruments.

For the full-rated anode dissipation of 500 kW and with inlet water at 60°C maximum, a flow of 54 gallons (200 liters) of water per minute must be passed through the anode cooler. At this flow rate the pressure drop across the anode cooler (not including the connector drop) will be approx. 5.8 psi (40 kPa). Maximum allowable outlet temperature is 100°C. System pressure should be limited to 75 psi (520 kPa).

Cooling water must be well filtered (with the equivalent of a 100-mesh screen) to eliminate any solid materials which could block cooling passages, as this would immediately affect cooling efficiency and could produce localized anode overheating and tube failure.

For more detailed information, applications Bulletin #AB-16, "Water Purity Requirements in Liquid Cooling Systems" is available upon request.

BASE COOLING – In a typical transmitter, the tube base requires air cooling. A minimum of 56 cfm (1.6 m3 / min) of air at 25°C max at sea level is forced through the socket from a high-pressure blower. The maximum air inlet temperature is 45°C and the blower must be able of supplying this flow at a back pressure of 256 mm of water. Temperatures of the ceramic/metal seals and the lower envelope areas are the controlling and final limiting factor and the maximum allowable temperature in these areas is 200°C. Temperature-sensitive paints are available for use in checking temperatures in these areas before equipment design and air-cooling arrangements are finalized. Well- filtered air must be supplied at suitable flow and temperature. Application Bulletin #20 TEMPERATURE MEASUREMENTS WITH EIMAC POWER TUBES is available upon request.

Both anode and base cooling must be applied simul-taneously with the application of electrode voltages, including that of the tube filament. Cooling should continue for about three minutes after removal of electrode voltages to allow the tube to cool down properly.

ELECTRICAL

ABSOLUTE MAXIMUM RATINGS – The values shown for the type of service is based on the "absolute system" and are not to be exceeded under any service conditions. Exceeding these values may damage the tube. To avoid exceeding the absolute ratings, the equipment designer should determine an average design value for each rating that is below the absolute value of that rating 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.

The ratings shown are for an rf amplifier in amplitude modulated service. If the designer intends to use the tube in another type of service (CW, pulsed, etc.) the absolute maximum ratings may be different. Please contact CPI Microwave Power Products Eimac Operation for details and revised ratings.

FILAMENT OPERATION – When cold, the resistance of a thoriated tungsten filament is very low, therefore the initial starting current when voltage is applied can be many times the normal (hot) current; this can be detriment to the longevity of a filament structure. Filament inrush current should never exceed a value of approx. twice the nominal rated (operating) current, ie. inrush (surge) current should not exceed 1000 Amperes during the first cycle after voltage is applied to the filament. See section on Filament Ramp-Up/Down on p.4 for specific information.

OPERATIONAL PROCEDURE – A new tube should have the filament voltage maintained at 23.0 Volts (rms or dc) for approx. 30 minutes or longer, prior to the application of any other tube voltages, for conditioning the tube. Filament voltage should be measured directly at the tube socket with an accurate rms-responding meter (in the case of ac voltage). Following this, output power should be increased gradually in steps until it is stable then finally at its rated maximum; never run full power immediately on a tube that has been in storage or has not been conditioned recently.

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In actual practice the operating filament voltage can be less than the nominal value and it should be reduced for long filament life (also see section on extending tube life below). The control and screen grid power dissipations, when high, can produce additional heat to the filament resulting in a higher than desired filament operating temperature. This can, over time, reduce overall filament life by prematurely decarburizing the filament. Under certain conditions such as testing under full power for proof of performance with continuous tone modulation or whenever the tube's grids are being operated near their maximum dissipation ratings, a temporary reduction in filament voltage may be recommendable.

FILAMENT CYCLING – Excessive filament thermal cycling can cause mechanical distortion of the filament structure and resulting degradation in the tube's electrical performance. For optimum tube life the average filament on/off cycle rate should not exceed 1 cycle per day.

Following CPI's standby mode procedure (see below) does not constitute an on/off cycle each time the filament voltage is reduced to the recommended standby potential.

EXTENDING TUBE LIFE – At the rated (nominal) filament voltage the peak emission capability of a tube is many times that needed for normal service. A reduction in filament voltage should be determined for the particular application. The tube should 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. The voltage should then be gradually reduced until there is a slight degradation in performance, such as decreased power output or distortion, while operating at the rated maximum transmitter output. The filament voltage should then be increased a few tenths of a volt above the value where performance degradation was noted. The operating point should be rechecked after 24 hours. Filament voltage should be closely regulated when voltage is to be reduced below nominal, to avoid any adverse influence by normal line voltage variations. Filament voltage should be measured at the tube base or socket, using an accurate rms-responding meter. To ensure maximum tube life, periodically repeat the procedure for reduction of voltage outlined above, resetting voltage as required.

For more detailed information, Application Bulletin #AB-18, "Extending Transmitter Tube Life," is available upon request.

STANDBY MODE – During periods of extended standby service, filament life may be increased by an additional reduction in filament voltage. Note however that the filament voltage should never be less than 85% of the rated nominal value; a general recommendation is to set the filament to 19.5 V during periods of extended standby service. Black-heat operation (a reduction of filament voltage to 50% or less of nominal voltage) is not recommended but a program of this type may be undertaken if performed carefully so as to prevent poisoning the filament. During standby periods, forced air cooling must be maintained on the tube to ensure the ceramic/metal seal temperature does not exceed 200°C. During standby, anode cooling water flow must be maintained at a rate that ensures the outlet water temperature never exceeds 85°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 RAMP UP/DOWN – The filament supply should ideally raise voltage gradually over a period of approx. 90 seconds from a cold start. Conversely, lowering the filament voltage from its operating voltage to zero over a similar period (90 secs) before shutting down the transmitter is also desirable. In the case of a fault condition which removes filament voltage for a period of less than 30 seconds, the full filament voltage may be re-applied immediately. If the off-time is greater than 30 seconds however, it is recommended the linear programmed ramp up of 90 seconds be used.

GRID OPERATION – The maximum rated control grid dissipation for the 4CM500,000G is 3000 watts, and can be 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 control grid and 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 voltage decreases the grid current. As a result, large values of instantaneous negative grid current can be produced, causing the amplifier to become regenerative. The driver stage must be designed to tolerate this condition. One technique used to stabilize the grid is to dissipate some drive power in a non-reactive load so that any change in the overall grid impedance due to secondary grid emission is a small percentage of the total driver load.

SCREEN OPERATION – The maximum rated screen grid dissipation for the 4CM500,000G is 8000 watts. With no ac voltage (modulation) 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. Anode voltage, anode loading or grid bias voltage must never be removed while filament and screen voltages are present, because screen dissipation ratings would be exceeded. A protective spark-gap device should be connected between the screen grid and the cathode to guard against excessive voltage. The tube may exhibit reverse screen current to a greater or lesser degree depending on operating conditions. The screen power supply should 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. A series regulated power supply can be used only when an adequate bleeder resistor is provided.

ANODE DISSIPATION – The maximum operating anode dissipation is 500 kilowatts, attainable with proper flow characteristics, and provides a margin of safety in most applications. This rating may be exceeded briefly during tuning. When the tube is used as an anode-modulated rf amplifier anode dissipation under carrier conditions should be limited to approx. 350 kilowatts.

FAULT PROTECTION – In addition to using the normal anode over-current, screen current and coolant interlocks, the tube must be protected from damage caused by an internal arc which may occur at high anode voltage. No more than 50 joules of energy may be dissipated in the tube structure.

An electronic crowbar is recommended for the anode supply. This type of protection circuit will discharge power supply filter capacitors in a few microseconds after the start of an arc. A fast acting interruptor is an alternative to a crowbar circuit but the type of switching device must be specified properly to achieve the 50 joule limit.

To conduct a protection test for each electrode supply which will verify adequate tube protection, short circuit each HV power supply to ground through a vacuum switch or other suitable high-speed, high-voltage switch and a 6-inch (15.24 cm) length of #30 AWG (0.255 mm) soft copper wire. If the total energy delivered is less than 50 joules, the wire will remain intact, verifying adequate protection. For more detailed information, application Bulletin #17, "Fault Protection" is available upon request.

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 deterioration, due to leakage 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 equipment X-ray survey. Operating high voltage equipment with interlock switches "cheated" and cabinet doors open in order to locate an equipment malfunction can result in serious X-ray exposure.

HIGH VOLTAGE – Normal operating voltages used with this tube are deadly. 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.

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 effect. Public health agencies are concerned with the hazard, and the published OSHA (Occupational Safety and Health Administration) or other local recommendations to limit prolonged exposure of rf radiation should be followed.

INTERELECTRODE CAPACITANCE – The actual internal electrode 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. Testing is performed on a cold tube. The capacitance values shown in the technical data are taken with no special shielding. 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 significant in design.

SPECIAL APPLICATIONS – To operate this tube under conditions different from those listed here, contact CPI Microwave Power Products Eimac Operation, Applications Engineering, 607 Hansen Way, Palo Alto, CA 94304 USA tel. 1-800-414-8823 or powergrid@cpii.com

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 and are exposed to power tubes, or equipment that 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.

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

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.

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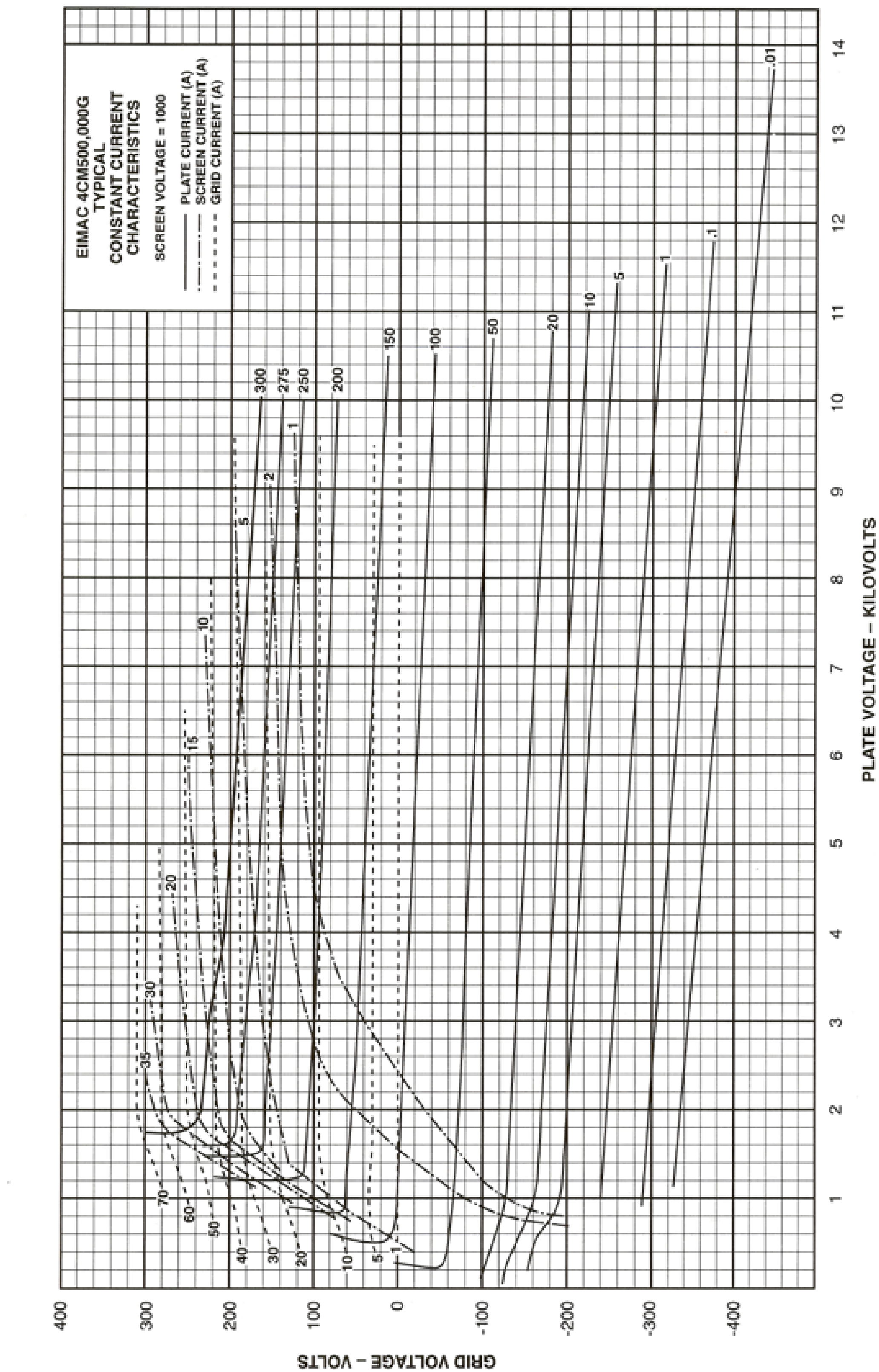

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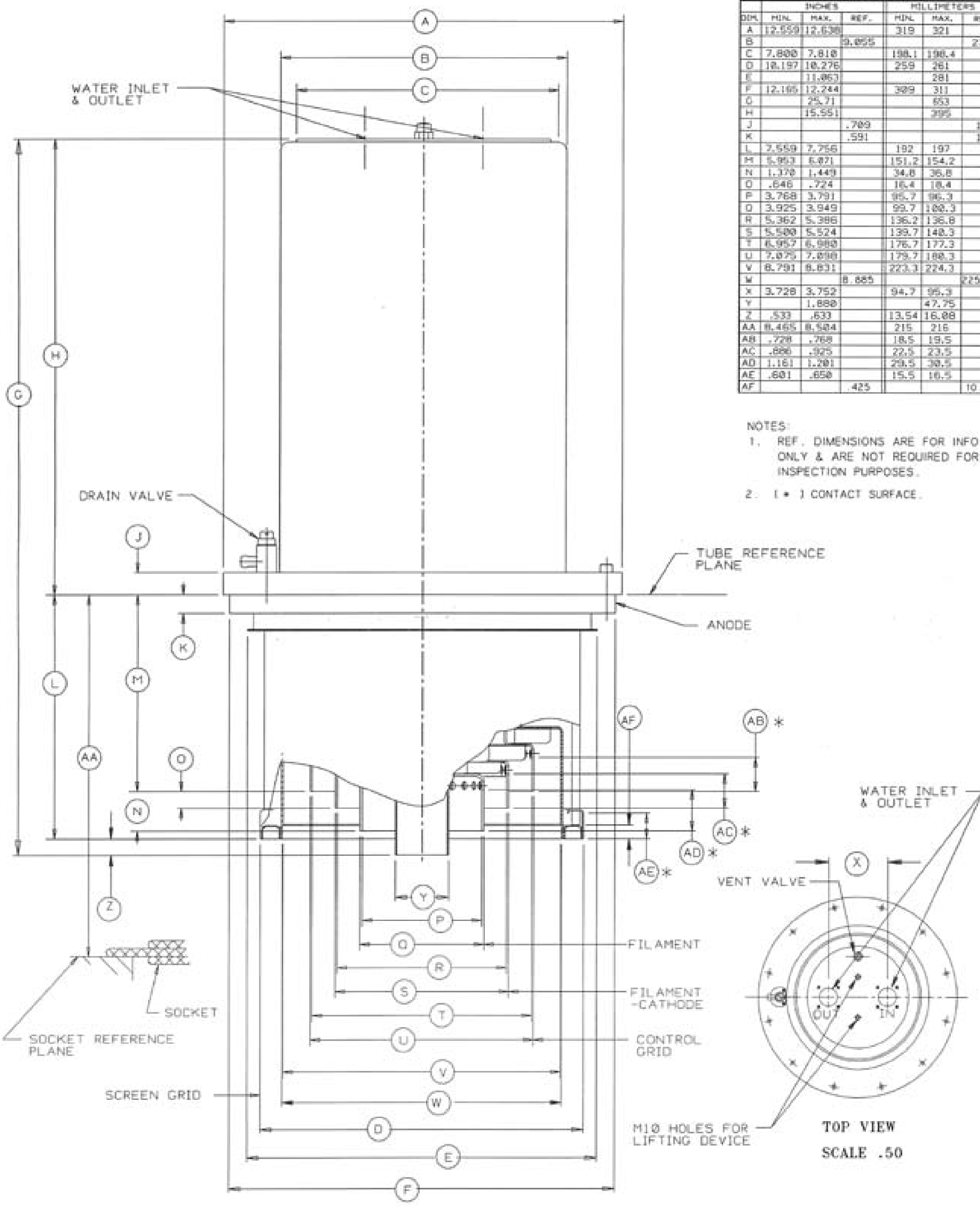

DIMENSIONAL DATA						
	INCHES			MILLIMETERS		
DIM.	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	12.559	12.638		319	321	
B			9.055			230
C	7.800	7.810		198.1	198.4	
D	10.197	10.276		259	261	
E		11.063			281	
F	12.165	12.244		309	311	
G		25.71			653	
H		15.551			395	
J			.709			18
K			.591			15
L	7.559	7.756		192	197	
M	5.953	6.071		151.2	154.2	
N	1.370	1.449		34.8	36.8	
O	.646	.724		16.4	18.4	
P	3.768	3.791		95.7	96.3	
Q	3.925	3.949		99.7	100.3	
R	5.362	5.386		136.2	136.8	
S	5.500	5.524		139.7	140.3	
T	6.957	6.980		176.7	177.3	
U	7.075	7.098		179.7	180.3	
V	8.791	8.831		223.3	224.3	
W			8.885			225.68
X	3.728	3.752		94.7	95.3	
Y		1.880			47.75	
Z	.533	.633		13.54	16.08	
AA	8.465	8.504		215	216	
AB	.728	.768		18.5	19.5	
AC	.886	.925		22.5	23.5	
AD	1.161	1.201		29.5	30.5	
AE	.601	.650		15.5	16.5	
AF			.425			10.80

NOTES:

1. REF. DIMENSIONS ARE FOR INFO ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES.
2. [*] CONTACT SURFACE.