APPLICATION BULLETIN

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SAN BRUNO, CALIFORNIA

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PULSE SERVICE NOTES

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PULSE SERVICE NOTES

In pulse service, where the "on-time" is small compared to the "off-time," Eimac tubes with their ample reserve of filament emission and freedom from internal insulators can be run to a much higher peak-power than is permissible in continuous services. In continuous service, the published voltage and current maxima of Eimac tubes are generally set at values considerably less than the inherent limitations of the design, due to the need to consider the average power dissipated on the anode, grids, and entire tube structure. In pulse service, it is usually reasonable to increase the applied electrode voltages and resulting pulse currents above the maximum values shown for continuous service on the data sheets.

Because of the wide variety of operating conditions in pulse service, it seems advisable to indicate possibilities of tube performance rather than specific operating conditions. It is the user's responsibility to see that no basic limitations of the tubes are exceeded and to introduce factors of safety according to the needs of the particular application.

The principal basic limitations of the tube are given below:

1. **Average Electrode Dissipation.** The dissipation limits of the electrodes are given on the tube data sheet and usually under Radio Frequency Power Amplifier or Oscillator Service. The dissipation must be average over a full repeated pulse cycle. The length of the applied pulse must not be so great that the temperature rises excessively on any one pulse. Pulse times as high as 0.1 second are often not unreasonable. Above about 0.1 seconds the rise in temperature of the electrodes rather than the average power during the pulse becomes the basic limitation and this type of service is discussed under Item 5, "Long Pulse Operation."

   Usually, the average electrode dissipation is the product of the dissipation on the element during the on-time, multiplied by the duty cycle (ratio of on-time to a full cycle time). This assumes that the pulse is essentially a square wave. The dissipation may be considerably greater if intermediate values of current between zero and the maximum value flow for appreciable time. Sometimes uneven heating of an element may be a further limitation. In the case of a radiation-cooled anode, this effect is apparent and the temperature of the hottest spot should not be allowed to exceed the normal maximum anode temperature.

2. **Envelope and Seal Temperatures.** The temperature requirements of the bulb and seals will be met if the ordinary cooling instructions are followed. In continuous radio frequency service, a limiting upper frequency is usually specified above which operation at reduced ratings or increased cooling is recommended. In pulse service above this frequency, care should be taken to see that the heating of the leads due to rf charging currents will not be greater than normal.

3. **Available Cathode Emission.** In continuous service, the tube currents are usually limited by dissipation of the electrodes and for convenience are given in terms of dc components read on a meter external to the tube. In pulse service, one needs to know the available total cathode emission in order to engineer the application.

   With thoriated tungsten filaments operating at rated voltage in Eimac tubes, the available emission throughout life is above 80 milliamperes per watt of filament power. By raising the filament voltage 10%, this figure can be approximately doubled. Above 10%, the emission will not be further increased, except for short periods of time due to the failure to maintain the optimum emitting surface conditions.

   With oxide coated cathodes, the available peak emission is not clearly defined or as easily generalized as in the case of thoriated tungsten fila-

When, in 1936, government engineers first tried Eimac tubes as pulsed oscillators, radar became a reality in the United States. The ability of standard Eimac tube types to withstand voltages many times in excess of their maximum CW ratings and to deliver high orders of emission current over relatively long periods of time made possible the attainment of the high peak power required for a practical radar system.

Throughout the years since 1936, the development of improved pulse equipment has been paced by new Eimac tubes and the continual improvement of existing types for better and more reliable operation under pulsed conditions.

Important milestones in the use of Eimac tubes in pulse service are:

Eimac 100T tubes used as pulsed VHF oscillators in the Navy's first radar tests at sea aboard the USS New York in 1938.

Eimac VT-127's, a modification of the 100T used as oscillators and Eimac 304T's used as modulators in the SCR-268, one of the Army's first radar sets.

Eimac 15E and 15R miniature transmitting tubes developed for and used as pulsed oscillators and high voltage rectifiers in ASB airborn search radar.

Eimac 327A and 227A tubes developed for use as pulsed oscillators in Navy search radar sets of the SC and SK series.

Eimac 527 tube developed for and used in SK-1M and SR radar for high-power search.

Eimac 1000T, later modified for mass production and designated 6C21, used as modulator for the Armys famous SCR-584 radar.

During World War II Eimac produced nearly 2 million tubes of its own design for pulse service. In the process of developing and producing these tubes Eimac has gained "know how" about the pulse operation of tubes which is unequaled in the vacuum tube industry. This knowledge has made it possible to develop new tubes having outstanding characteristics for pulse operation. Among these tubes are oscillators and amplifiers capable of delivering pulse powers from a few tens of kilowatts to megawatts and modulators which will key currents from a few amperes to hundreds of amperes.

Years of experience have been gained regarding the pulse capabilities of standard Eimac types. Some of this information is presented on the following pages. However, many pulse applications are so specialized in nature that they do not lend themselves to general rules or tabular presentation. If your problem is of this sort, avail yourself of the services of the Eimac Field Engineering Department.

ments. It appears that the available emission for pulse work in typical oxide coated cathodes used in Eimac tubes can conservatively be estimated as 500 ma. per watt of heater power. This figure assumes that the pulse duration is not over about 3 micro-seconds. There is some evidence that above 3 micro-seconds, the maximum usable space current may have to be reduced.

4. VOLTAGE INSULATION. The breakdown voltage of Eimac tubes is usually well above the values given for continuous service. The basic limit is related to the maximum instantaneous voltage applied to the anode of the tube at any instant. It is also somewhat affected by the regulation of the supply voltage and length of time the voltage is applied. The accompanying table is a rough guide to the values of dc anode voltage that can be applied to the tube.

5. LONG PULSE OPERATION. When the length of the applied pulse exceeds about 0.1 seconds (100 milliseconds) the power limitation is no longer the average power dissipated on the electrodes and one must consider the temperature rise of the electrodes (principally the grid wires) during the time the pulse is on. If the pulse duration is in excess of 2.5 seconds the tube must be treated as in continuous service and the normal data sheet ratings apply.

   The maximum capabilities of a thoriated tungsten tube in pulse service when the pulse duration is between 0.1 seconds and 2.5 seconds can be computed by using the accompanying curve and table.

   As long as the off-time between pulses is 5 seconds or more the pulse may be repeated even though the maximum tube capability for a given pulse length is utilized. Because the grid dissipation is the principal limitation, the curve and table give factors to compute the permissible grid dissipation during the pulse. The product of the two factors is the number of times the rated grid dissipation can be exceeded for a given pulse duration. The factor from the curve is to be used directly for the plate and screen dissipation.

When first running up the voltage on a tube in pulse service, or after the tube has been idle for some time occasional internal flash breakdowns in a tube are to be expected. The circuit should be designed so that the high rush of current and resulting high transient voltage surges will not be destructive to equipment. The transients, due to momentary breakdown of the insulation of the vacuum space, have very high frequency components. As a consequence, high voltages will develop across small lead inductances. Spark gaps, bypass capacitors and inductance filters are often used to dissipate or divert this energy into harmless channels.

Protective devices should be designed to remove the applied voltage quickly when a breakdown occurs. If overload protective action is fast, and the regulation of the source voltage poor enough, no damage to the tube will result and operation can be resumed.

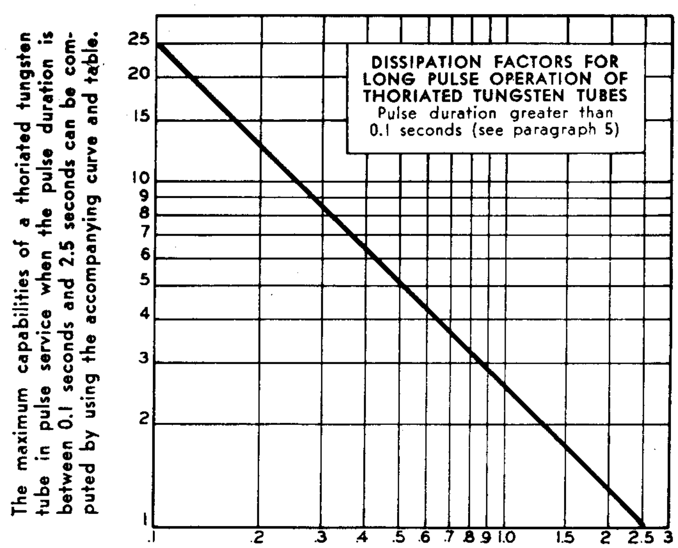
No guarantee is made that the tube will not break down at the voltages given on the chart. It is estimated from considerable experience that these are approximately safe maximum values to be considered in design work.

▶ Indicates Revision

MAXIMUM RATINGS FOR PULSED SERVICE

Tube Type	MAXIMUM PLATE VOLTAGE: RF Service Plate Pulsed Kilovolts	RF Service Grid Pulsed Kilovolts	Pulse Modulator Service Kilovolts	Max. Screen Voltage Kilovolts	Grid Factor Long Pulse Operation*
▶ 2C39A	3.5	....	....	....	....
3C24	10	7.5	15	....	.68
3X2500A3	15	10	25	....	.68
3X2500F3	15	10	25	....	.68
▶ 3W5000A3	15	10	25	....	.68
▶ 3W5000F3	15	10	25	....	.68
4E27A/5-125B	12	9	18	2.0	1.68
4-65A	10	7.5	15	2.0	.57
4-125A	12	9	18	2.0	1.87
4-250A	15	10	20	2.5	2.7
4-400A	15	10	20	2.5	2.7
4-1000A	20	15	30	2.5	1.54
4PR60A	....	....	20	1.5	....
4X150A	2	....	3	1.0	....
▶ 4X150D	2	....	3	1.0	....
4X150G	2	....	3	1.0	....
4X500A	10	7.5	15	2.0	.95
4X500F	10	7.5	15	2.0	.95
6C21	20	15	30	....	....
15E	12.5	10	15	....	....
25T	10	7.5	15	....	.77
35T	10	7.5	15	....	.84
35TG	10	7.5	15	....	.84
UH-50	5	4	7.5	....	....
75TH	12	9	17	....	.67
75TL	12	9	17	....	.62
100TH	15	10	20	....	1.01
100TL	15	10	20	....	1.11
152TH	12	9	18	....	.71
152TL	12	9	18	....	.65
250TH	18	15	25	....	1.03
250TL	18	15	25	....	.89
304TH	12	9	18	....	.71
304TL	12	9	18	....	.65
327A	20	15	30	....	....
450TH	20	15	30	....	1.09
450TL	20	15	30	....	1.0
527	20	18	30	....	....
592/3-200A3	18	15	25	....	.80
750TL	20	15	30	....	1.09
1000T	20	15	30	....	1.1
1500T	20	15	30	....	1.61
2000T	20	15	30	....	1.8

*Combine with factor taken from curve for various pulse duration times.



PULSE DURATION (Seconds)