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Voltage Regulator Tubes

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Use of voltage regulator tubes in military equipment is increasing. As the many uses for these tubes increase, difficulties encountered in their applications will likewise increase. Certain fundamental characteristics of a voltage-regulator tube must be considered if reliability and satisfactory performance are to be obtained.

Voltage regulator tubes are usually recommended for use under various conditions of current drain from 5 milliamperes to 30 or 40 milliamperes as shown in Table I.

Essentially, voltage-regulator tubes of the glow-discharge variety contain a cathode, usually cylindrical in shape, of relatively large area, and a relatively small anode. Upon the cathode is deposited a thin film of some material that serves as an activator. The electrodes are sealed in a bulb containing an inert gas—argon, helium, neon, krypton or a mixture of gases at pressures that may be as low as a few millimeters to more than a centimeter of mercury, depending upon the operating conditions under which regulation is desired. Figure 1 indicates the basic structure of a glow-type regulator tube.

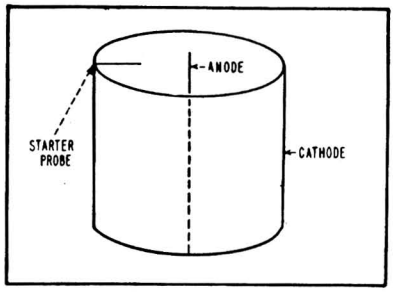

FIG. 1—Voltage-regulator tube structure

Table I shows that the minimum plate current for these tubes is 5 milliamperes while the maximum varies from 30 to 40 milliamperes depending upon the tube type. Frequently a voltage regulator tube is employed as a reference tube where the drain is less than 5 milliamperes. Erratic performance is obtained under these conditions owing to the fact that only a small amount of the cathode surface is covered by the glow.

In applications of this sort the use of a voltage-reference tube is required if reliable operation is to be obtained. In instances where a reference tube is not employed, the current drain must be increased to at least 5 milliamperes if satisfactory operation is to be obtained with a voltage-regulator tube.

The second part of Table I shows the characteristics of two voltage-reference tubes that are currently available.

It is a characteristic of glow-regulator tubes that the current density remains constant so that the cross-sectional area over which current flows varies instead. Thus when the current is small, the glow does not cover the whole of the cathode surface but concentrates on a part of it. As the current is increased, the area of the cathode covered by the glow increases linearly with the total current.

Under many conditions of operation if the voltage-regulator tube is observed it will be noticed that the active glow area within the tube shifts considerably. This shifting that occurs within the tube accounts for small variations in the regulated voltage developed across the tube itself. This effect is sometimes referred to as jitters.

During the long-time life of the tube the voltage regulation may change and the regulated voltage will increase. This results from partial cleaning up of the activator during life.

If the regulator tube is subjected to very high starting currents, the regulated voltage may require as long as 20 to 30 minutes to drop to its normal operating voltage. The regulation is affected by changes in current within the operating range. Thus, if a tube that has been operating for a long time at low current is suddenly changed to higher current the regulated voltage value may be somewhat different from the value obtained after a long period of time at the

Table I—Voltage Regulator and Reference Tubes

Tube type	Minimum current in ma	Maximum current in ma	Maximum breakdown D-C volts	D-C operating volts	Minimum breakdown in darkness D-C volts**
OA2*.....	5	30	185	150	225
OA3*.....	5	40	105	75	160
VR75					
OB2*.....	5	30	133	108	210
OB3.....	5	30	130	90	175
OC3.....	5	40	133	105	210
VR105					
VR150.....	5	40	185	150	225
5644*.....	5	25	130	95	***
5787.....	5	30	141	100	***
6073.....	5	30	185	150	***
6074.....	5	30	133	108	***
		Voltage Reference Tubes			
5651*.....	1.5	3.5	115	87	160
5783.....	1.5	3.5	125	87	***

* Armed Services Preferred List.

** This is the minimum value if tube is held in dark for 24 hours before testing and tested in total darkness.

*** These values for the darkness test are currently being determined.

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higher current value. If a voltage-regulator tube is not used for awhile the regulated voltage will likewise require considerable time before it becomes stabilized.

The minimum d-c voltage required for breakdown of various voltage regulator tubes is shown in Table I. Voltages somewhat in excess of the values shown must be available to be certain that the tube will completely ionize so the proper d-c regulated voltages will be obtained. These values are also shown in Table I.

Ionization of these tubes is accomplished from three sources: photoelectric effects on the cathode from external light sources, radioactive effects from radiation and finally the field owing to voltage applied between the cathode and anode of the tube. The sum of these effects establishes the value of minimum breakdown voltage shown in Table I. If now the tube is operated under conditions of total darkness, then more voltage, perhaps as much as 50 or 60 volts, will be required for breakdown since the contribution from photoelectric radiation has been removed. Likewise, if the tube is mounted where radioactive radiation is completely removed, the breakdown voltage will also be increased.

It is important to determine whether the published ratings cover operation in the dark or in lighted areas. The conditions are specified on the rating sheets and these values will not be realized in service unless the operating conditions duplicate those under which the production tests are conducted.

Often it is desirable to shunt the voltage-regulator tube with a capacitor. It is necessary to keep the value of capacitance at or below 0.1 μf. If this value is exceeded instability and oscillations may occur.

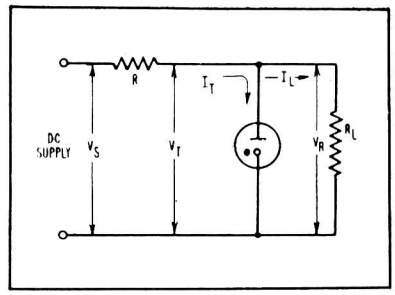

FIG. 2—Parameters for proper operation explained in text

In this discussion it has been assumed that the proper circuit design has already been completed. If the voltage regulator tube is to operate within its rated conditions there are three conditions that must be satisfied. These limiting conditions are given in Table I for several types of voltage regulator tubes.

Referring to Fig. 2 these conditions are:

(1) The voltage V_T supplied to the tube before firing is equal to or exceeds the minimum breakdown voltage specified in Table I. Thus the d-c supply voltage V_s must equal V_T plus the voltage drop across R when the only current flowing is that due to the load R_L.

(2) The current I_T flowing through the tube after breakdown is held above the minimum permissible value shown in Table I.

(3) The current I_T flowing through the tube after breakdown will not exceed the maximum value shown in Table I even if the load current should be reduced nearly to zero.

BIBLIOGRAPHY

R. C. Miles, How to Design VR Tube Circuits, ELECTRONICS, p 135, Oct. 52.

In Table I, tube types designated VR75, VR105, and VR150 now have the commercial designations 0A3, 0C3, and 0D3, respectively.