TP-117
Power Tube

Application Note

Handling and Operating Considerations When Using BURLE Broadcast-Type Tetrodes

Introduction

BURLE power tetrodes are reliable electronic devices designed for high efficiency and performance. With careful handling and diligent compliance with recommended operating practices, long tube life can be attained. This note will help operators of BURLE power tetrodes to utilize all of the features built into these tubes and to achieve long tube life.

Handling

Handle BURLE CERMOLOX[R] tubeswith care. The shock of placing a tube directly on a hard surface such as concreteflooring or a wooden bench top is likely to cause internal tubedamage. The shipping container is designed to cushion the tube. Use the shipping container as a holder to cradle the tube.

NEVER tap the tube with a mallet. The shock from a light plastic mallet is sufficient to severely damage a "basket-weave" thoriated-tungsten filament.

Shipping

Each BURLE power tube is packaged in a container designed to safeguard the contents against bumps, shocks and other rough handling and to assure the tube's arrival at its destination in good operating condition. If a tube is received with its shipping container in damaged condition, the shipper should be notified immediately. Also report damage to the ceramic-to-metal envelope. BURLE CERMOLOX tetrodes have many performance advantages, but visual examination of the tube's internal structure is impossible through the ceramic. Transportation damage may occur in CERMOLOX tubes, especially to the filament, which is not detectable with the usual ohmmeter check. Therefore, all new tubes should be unpacked and run in typical operation for two to three days. Monitor filament voltage and filament current carefully to assure normal filament, as well as tube, operation.

Socketing

BURLE CERMOLOX tubes operate in cavities or sockets especially designed for them. Contact fingers engage each element simultaneously. These contact fingers must be clean and unbroken, free from burns or arcing. If more than three fingers are missing from a particular ring or have lost their temper, the entire ring should be replaced. Oxidized or dirty contacts may be cleaned with crocus cloth or with "Scotch-brite" Type A, a fine abrasive cleaning pad. Contact fingers that appear overheated should be bent inward slightly after cleaning to increase contact pressure.

When socketing a tube, begin the insertion by pressing the tube straight into the socket fingers and then rotate the tube to settle it into the socket contact surfaces. Do not insert or remove the tube by rocking the tube back and forth. This action crushes the contact fingers and can apply undue force to the internal structure of the tube.

BURLE Electron Tubes

Tube Ratings

Each tube type is rated for specific maximum parameters. BURLE assures that the tube will perform satisfactorily at these levels within the warranty. Additional life can be gained by operating below these maximum ratings.

CERMOLOX tubes are generally rated at **250°** C maximum seal and anode core temperatures. As a general rule, tubes should be operated 25° to 50° below this figure as a safety factor. The air flow needed to cool the tube to this value and below can be found in the particular tube data sheet. Because of the small size of most broadcast CERMOLOX tubes and their higher gain and superior linearity, added consideration must be paid to assure adequate cooling of the tube. Short, straight air paths should be used to maximize the cooling efficiency of the system. Specific air flow calculations are covered in a separate publication, Application Note TP-118.

Voltage ratings are limiting characteristics within which a tube can safely operate. Avoid socket designs which may reduce breakdown voltage by protruding into the electrode-to-electrode separation. Contact rings may require shielding to avoid electrode-to-ground shorts. For example, position screen-grid contact fingers so they do not present a short, sharp path from anode to ground. It is wise to operate tubes well below their maximum ratings, especially in new equipment designs. Numerous changes in specifications during the equipment design cycle often necessitate increased screen and anode potentials. High and low line conditions should also be considered to assure operating voltages stay within rated limits.

Current and dissipation ratings are limited by a tube's materials and design and by the various electrical stresses of differing applications. The tube must be operated within these ratings to achieve satisfactory life and stable operation. Screen dissipation is usually the most difficult parameter to control effectively.

To avoid screen over-dissipation, never apply screen voltage before anode voltage. Likewise, never permit screen voltage to remain ON after removal of anode voltage. During initial equipment tuning, carefully adjust anode loading to avoid screen over-dissipation. Screen dissipation is a function of screen voltage and positive screen current, not measured screen current. For example, CERMOLOX matrix oxide tubes operate with negative screen current because primary and secondary screen emission exceeds positive screen current. Use a resistive bleeder to draw at least as much positive screen current from the supply as the magnitude of the expected negative screen current. For a more detailed description of screen current loading in tetrodes, refer to BURLE Application Note TP-122.

Filament

The filament of BURLE broadcast type tetrodes of the CERMOLOX family is referred to as a "basket weave", mesh type filament. These filaments are less susceptible to shock and vibration than hair-pin or straight "bar" type filaments. They are less prone to bow with use, and they lend themselves to high transconductance, close-spaced structures. However, it must be remembered that they are made from carburized, thoriated-tungsten wire and hence are quite brittle, particularly at room temperature. Handling is the major cause of broken filaments.

Filament Voltage and Current

Filament voltage should be measured with an accurate rms meter such as an iron-vane or thermocouple type. Common rectifier type meters should not be relied upon, they should be used only as monitors. Filament current can be read accurately with either a calibrated shunt and an oscilloscope or a current transformer and a meter. Clamp-on ammeters are subject to error if not properly used, but can provide good information if employed correctly. Care should be taken to make sure each range is calibrated and that the jaws are firmly together when in place around the conductor.

Filament Warm-up

Most filamentary tubes used in transmitter service are rated for 15 seconds minimum heating time. This warm-up is necessary to allow the grids and the filament to reach an equilibrium temperature and avoid arcing due to momentary shorting between these elements after the application of high voltage. Shortened warm-up time cycles can be used by step-starting the filament. It is possible to start tubes with as little as 3 seconds heating time, but this procedure can cause subtle internal changes which may result in shortened life times. Such short cycles may be used as emergency starts, but never as normal procedure. In most cases, it is advantageous to use the full recommended minimum heating time, then apply the other voltages before drawing full plate current.

This technique results in less thermal stress to all the elements concerned and assists in prolonging tube life. It is good practice to allow filaments to run continuously and minimize start-up stresses. If this method is impractical, the filament should be preheated for 10 to 15 minutes before the application of any other voltages. This procedure can substantially increase tube life expectancy. During starting, it is also important to limit initial filament current surges to the value listed in the particular tube bulletin. The ratio of hot to cold resistance of thoriated tungsten wire is about 10:1. If the applied voltage were supplied by a low impedance filament supply, starting currents could reach as high as 1500 A for the 8807, as an example, where the maximum permissible current is 300 A. In a practical application, surge currents of 600 to 700 amperes can be realized and these high surge currents will damage the filament structure.

Methods for holding surge currents below the limiting value include high reactance transformers, a resistive starting network or manual control of filament voltage by a Variac. A combination of the first two can also be used. Many new transmitters employ the "Pulsistor", a type of variable resistor. This device is placed in the filament primary circuit and it limits the surge current by changing resistance, having a high resistance when cold and a low resistance when hot.

Filament Life

The emission of the thoriated tungsten filament in a power tube is dependent on a monolayer of thorium on the surface of the wire. This layer is formed by the reaction of carbon with thoria. The end of tube life occurs when all the carbon is depleted from the filament structure. The physics of the filament are illustrated by the fact that theoretically for every 3% increase in filament voltage there is an increase of 20° Kelvin in the temperature of the filament, a 20% increase in peak emission and a 50% decrease in tube life. It is important, then, that filament voltage be checked accurately and regularly to assure operation within specified ratings. Good metering has already been mentioned and is important. Lack of such metering can, to some extent, be alleviated by operational testing. Some important criteria, such as sync compression or peak sync slipping, power output or distortion can be used to check tube performance. The tube is set up and the criteria measured or observed. Next, the filament voltage is reduced until degradation in the criteria observed is as much as can be tolerated. Filament voltage is then increased to slightly above the minimum value used in the test. Further checking in 12 to 24 hours should be done to insure stability at this filament voltage level.

It is recommended that the filament voltage be regulated by a constant voltage transformer such as a "Sola" unit. This regulation will play an important role in assuring extended tube life as shown above.

Voltage Sequence

Following the filament warm-up cycle and the application of grid-no. 1 voltage (bias) to the tube, high voltage should be applied to the anode at the same time or earlier than to the screen grid to insure against excessive grid-no.2 dissipation. In addition, at shut down, the grid-no.2 voltage must decrease along with or before the anode voltage. It is important that the grid-no.2 bypass capacitors not hold the screen voltage above that of the anode.

Cleanliness

Tube life can be severely shortened by allowing the tube ceramics to become dirty, precipitating arcs. If the tube ceramics become dirty, they can be cleaned carefully with such a preparation as "Glass Wax" when the tube is completely cool. Follow this cleaning with a 1, 1, 1 trichloroethane or isopropyl alcohol wipe. Periodically, all equipment air filters should be cleaned or replaced if necessary. This period may vary from 1 week in some locations to several weeks in others. The fin louvers will also become dirty and can be cleaned by carefully flushing the radiator with a stream of warm water directed at the louvers followed by air drying. Care must be taken in handling the tubes during all of these cleaning operations. A rubber or foam mat is ideal as a setting for the tube when performing the cleaning operations. Arc marks which have occurred can be removed by the gentle use of very fine emery paper after masking any adjacent ceramic to prevent buffing of the ceramic. All dust from this operation should be removed by a solvent wipe. The cause of the arc marks should be found and corrected before tube reinsertion.

Periodic Maintenance

Continuing attention to these items will improve tube life expectancy and reliability. Every installation will be different so the schedule of maintenance operation must also be developed individually based on environmental and operating considerations. In any event, voltages and currents must be monitored, filters cleaned or replaced, surfaces cleaned and connections tightened. All these should be scheduled as frequently as conditions indicate to assure long reliable life.