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Power Tube Applications

READ THOROUGHLY

Maximum Ratings—Maximum ratings are limiting values above which the serviceability of the tube may be impaired with respect to life and to satisfactory performance. The equipment designer has the responsibility of determining an average design value sufficiently below each maximum rating that the maximum values will never be exceeded under any condition of supply voltage variation or of load variation.

ITT power tube applications engineers are available to discuss any question which may arise concerning maximum ratings of these tubes. It is particularly recommended that they be consulted in the event it is proposed to design new equipment in which tubes will run at values greater than 85% of maximum under normal conditions.

Receiving-Inspection—All ITT tubes are x-rayed and are tested immediately prior to shipment. Despite the great care exercised in the design of the shipping containers and the care in selecting responsible freight forwarders, shipping damage does occasionally occur. Accordingly, all tubes should be inspected for both visible and invisible shipping damage immediately upon receipt. Any damage to the outer shipping container should be noted on the express receipt before it is signed. The container should be opened and both the tube and the inside of the container should be examined for evidence of any excessive rough handling during shipment.

Once it has been ascertained that no visible shipping damage is present, the tube should be installed in the equipment for which it is intended and operated after having followed the recommended break-in procedure. Meter readings and voltage settings should be compared with those experienced on tubes used previously. Any serious abnormalities should be discussed with your ITT field engineer to assess whether or not the tube may have hidden shipping damage. Filament current should be monitored with rated filament voltage applied. A clamp-on type ammeter is useful for this purpose if no filament current metering is included in the equipment instrumentation. The filament current should be within ± 5 per cent of the rated value. In cases where there is a question of meter accuracy, it should be within ± 5 per cent of that monitored on previous tubes. This is an important check because an abnormal reading can signify that the filament has been damaged. The filament structure may have many parallel electrical paths and the filament will appear to be intact if only a perfunctory check or an ohmeter continuity check is performed.

A shipping damage claim should be filed with the delivering carrier immediately upon discovering visible or hidden shipping damage. In order for the carrier to be able to honor such a claim, it must be filed within 7 days after receipt of the tube. Particular attention should be paid to hidden filament damage. Many equipments operate tubes very conservatively and tubes with this type of damage can often operate satisfactorily in such equipment for several hundred hours. Eventually, the portion of the filament which remained intact fails due to overheating. Many times the overheating causes the filament to bow and touch the grid.

Installation—New equipment should be designed with adequate clearance in the cabinet so that heavy tubes can be handled safely during installation and removal. On occasions where this has not proved practical, many astute manufacturers have provided their customers with special tools to lift particular tubes by the anode to facilitate safe installation.

Equipment manuals should stress periodic cooling system checks and an especially thorough check when a new tube is installed. Cleanliness of the envelope to insure high voltage holdoff and of connector surfaces to assure good electrical contact should also be emphasized. An undue amount of leverage should be avoided in tightening connectors.

Break-in Procedure—New tubes should be operated at normal rated filament voltage only, for thirty minutes before any other voltages are applied. Plate voltage should then be applied at the lowest possible value and increased gradually in steps over a period of an hour until the normal level is reached. This procedure will vary for individual tube types. Experience will determine if it may be shortened for smaller tubes or should be lengthened for larger tubes in a given application.

Storage—Tubes should be stored in a vertical position with the anode end down. They should be protected from extremes of heat and cold as well as from physical abuse. Every three months they should be given the break-in procedure outlined above and then operated at normal plate voltage for one hour.

Filament Care—The cathode of most of the tubes listed in this catalog is a structure of thoriated tungsten wire. There are a few older types listed which are still manufactured using bright tungsten cathodes. For the most part, the latter are made for replacement purposes only and, therefore, the comments here will be confined to thoriated tungsten cathodes.

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All of these cathodes are directly heated thus the cathode is really a filament, and the words filament and cathode are used interchangeably herein.

When a tube reaches a natural end-of-life condition it is usually because the emitting properties of the cathode have been exhausted. The life of this cathode and, therefore, the life of the tube can be extended many times beyond the normal 1000 hour warranty period if proper care is taken in the design of the equipment and if proper instructions on tube usage are passed along to the equipment users. Primary considerations in this respect are as follows.

1. **Filament starting**—The ratio of the hot to cold resistance of thoriated tungsten wire is approximately 10 to 1. Therefore, on a typical tube like the F-6696A, the nominal hot resistance would be 63.4 milliohms and the cold resistance would be 6.3 milliohms. If the rated voltage of 13 volts is applied to the cold filament without limiting current, the initial surge currents would be approximately 2000 amperes. Excessive starting current may easily warp or break a filament as the mechanical stress on the structure as a result of the magnetic field produced by this current is proportional to I_f^2.

   Consequently, current flow through a cold filament should be limited to 150% of the normal operating value for large tubes and 250% for medium types unless otherwise specified on a particular tube data sheet. The three most common methods of limiting this current are a high reactance transformer, manual control of the filament voltage either through a multi-tapped transformer or an auto transformer, or by means of a series of resistances in the filament circuit which are shorted out one at a time until rated voltage and current are achieved. ITT applications engineers can supply useful details on any of these methods.

2. **Maintaining proper voltage**—It is essential that the filament voltage on thoriated tungsten filaments be held to within $\pm 5\%$ of the rated value. Operation at high voltages will destroy the layer of tungsten carbide which protects the emitting layer and operation at low voltages will destroy the emitting layer itself either by shutting off the supply of thoria, or by reducing the space charge and thus subjecting the filament to increased ion bombardment. All transmitters or industrial heating equipment should include filament voltage metering. Not quite as essential but highly desirable, are filament current meters. The ability to monitor filament current is useful in performing a receiving inspection on new tubes, in performing filament processing when required and in predicting when a tube is approaching end-of-life condition.

3. **Filament recovery and processing**—Occasionally, a thoriated tungsten cathode which appears to have lost its emissive capabilities may be reactivated by applying filament voltage *only* in accordance with one of the following schedules.

   A. Apply 110% of rated value of filament voltage for a few hours or over night.

   B. If the emission fails to respond after schedule A, run at 30% above normal voltage for 10 minutes, then at 10% above normal for 20 to 30 minutes.

   C. In extreme cases, where A and B have failed to give results, and at the risk of burning out the filament, run at 75% above normal for 3 minutes followed by schedule B.

   This procedure is not effective in cases where the protective layer of tungsten carbide formed on the surface of the filament wire during manufacture has been severely depleted. This layer occupies a portion of the area cross-section of the wire and is relatively nonconductive. Its depletion is effected by reduction of the tungsten carbide back into tungsten which is a better conductor. Therefore, the conductance of the wire is effectively increased by decarburization. Accordingly, filament decarburization is accompanied by a rise in filament current. When filament current at rated filament voltage has risen to a value, 10% above that originally recorded at rated filament voltage, the tube is at or near end of life.

Handling—Tubes should be protected from shock and vibration during handling. Some tubes are quite heavy and require two people or proper materials handling equipment to transport them safely. They should always be handled by the anode and never by the envelope which would put an unreasonable amount of strain on the ceramic to metal or glass to metal seals.

Cleanliness—The equipment users should be encouraged to keep the tubes clean in order to encourage long life. A periodic maintenance check which includes cleaning the radiator fins on forced air cooled tubes and the anode itself on water or vapor cooled tubes will promote long life through improved heat transfer. Cleaning of non-glazed ceramic envelope areas with ordinary household cleanser or of glass or glazed ceramic envelopes with carbon tetrachloride to remove fingerprints and all other foreign matter will improve the insulating properties of these materials. This is extremely important as foreign matter on these surfaces will increase the probability of external arcing which could puncture the tube at the seal areas.

Fault Protection—High voltage arcing, whether internal or external, will destroy or impair a high vacuum tube. It is recommended that electronic crowbar circuit protection devices be installed in all high power equipment using these tubes and especially in those applications where such arcing is likely due to conditions of irregular line or load variations. Ball gaps or inert gas-filled spark gaps should be used across the tube terminals to protect against external arcing. ITT applications engineers can be of valuable assistance in providing information upon any aspect of tube protection.

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