ELECTRON TUBE DIVISION
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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.

Power Tube Applications

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 ±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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BOX 100 EASTON, PA 18043
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

TRANSMITTING TUBE SERVICE REPORT

(To be used for all Transmitting, Rectifier and Special Purpose Tubes)

ITT TYPE..... SERIAL NO. .....

In the event this tube should fail to give satisfactory service under the terms of our guarantee, it should be returned for inspection in accordance with the instructions on the reverse side of this form. This service report should accompany the tube and all questions should be answered fully AS NO ADJUSTMENT CAN BE CONSIDERED UNLESS COMPLETE INFORMATION IS GIVEN. It will be appreciated if this report is returned even though the tube has given satisfactory life so that the control of our tube quality may be facilitated.

Purchased From.....
Date Purchased..... Date First Tested.....
Date Placed in Service..... Date of Failure.....
Number of hours in service: With filament voltage only..... With all voltages applied.....
Nature of Defect.....
.....
Explain what happened at time tube failed.....
.....
.....
.....

CONDITIONS OF OPERATION

(For push-pull or parallel operation state whether values are for one or more tubes)

	No Signal, Unmodulated or Key-up	Full Signal, Modulated or Key-down	Stand-by
Filament Voltage--AC or DC?			
Plate Voltage			
Plate Current DC			
Grid Voltage			
Grid Current DC			
Screen Voltage			
Screen Current DC			
Suppressor Voltage			
Suppressor Current DC			
Water Flow Ga. per min.	Temp. of outlet water °C		
Air Flow CFM	Temp. of outlet air °C		

Type of bias supply and series resistor value.....
Source of screen voltage.....
Class of service..... Frequency.....
Make and Model No. of equipment in which tube was used.....

FOR RECTIFIER TUBES

Type of circuit.....
Maximum load DC output voltage..... Maximum load DC output current.....
Type of filter (condenser or choke input).....
Choke reactance..... Henries Condenser..... Mfds.

Customer's Name..... Signature .....
Street Address.....
City..... State .....

In returning an ITT tube for test and inspection, the customer gives permission to ITT to break the glass bulb and to dissect the tube, in case such procedure is considered necessary, for a complete examination to determine whether failure was caused by a manufacturing defect. Moreover, the customer agrees that, in the event such procedure is necessary, he will not hold ITT liable for the return of any tube so dissected.

TRANSPORTATION DAMAGE

All transmitting tubes should be given a thorough visual inspection and should be tested for continuity and short circuits immediately upon delivery. If found to be in normal condition, they should then be tested under load in the equipment in which they are to be used.

MECHANICAL DEFECTS SUCH AS LOOSE, SHORTED OR OPEN ELEMENTS, OPEN FILAMENTS, CRACKED OR BROKEN GLASS, ETC., ARE INDICATIVE OF MISHANDLING IN TRANSPORTATION. If such a condition is found, a damage claim should be filed immediately with the local agent of the transportation company and the tube and its shipping container should be held in exactly the condition received pending instructions from the transportation company.

PACKING AND SHIPPING INSTRUCTIONS

Tubes returned for inspection should be packed carefully in the original container and shipped via prepaid express to our Service Department at the following address:

ITT Electron Tube Division
3505 Hartley Avenue
Easton, Pennsylvania

ATTENTION: Electron Tube Receiving

THE RETURN SHIPMENT MUST BE MADE BY THE CARRIER THAT DELIVERED THE TUBE

Unusual care should be observed in packing tubes involved in adjustment claims, as proper attention cannot be given to a claim unless the tube is delivered to us in the exact condition existing at the time of failure. Therefore, if the original shipping container is not available, a new one may be obtained by writing to our Service Department at the above address, or the tube, unless unusually large in size, may be packed as follows: The tube should first be packed with excelsior or some suitable wadding in a box slightly larger than the tube. This package should then be floated in an outer shipping container sufficiently large to allow a minimum of four to six inches of wadding on all sides of the inner package. The outer container should be labeled with notations such as "Glass," "Fragile," "Handle With Care," etc.

OPERATING HAZARDS

READ THE FOLLOWING INSTRUCTIONS AND TAKE ALL THE NECESSARY PRECAUTIONS.

OPERATING INSTRUCTIONS

This information is provided to help you establish safe operating conditions for both you and your ITT Electron Tube.

Use the Tube Data Sheet and Operating Instructions with the information given in this sheet to help you operate this tube in a safe and efficient manner. The Tube Data Sheet provides the general characteristics and maximum ratings for the tube. The Operating Instructions give special considerations and precautions to be followed to obtain best performance.

Do not operate this tube except in accordance with proper operating instructions, these precautions, and any additional information provided by ITT Electron Tube Division representatives. Address any questions regarding the safe and proper use of this tube to:

ITT Electron Tube Division
P.O. Box 100
Easton, Pennsylvania 18042

WARNING—SERIOUS HAZARDS EXIST IN THE OPERATION OF ALL TUBES

The operation of all electron tubes involve the following hazards:

a. HIGH VOLTAGE—Normal operating voltage can be deadly.
b. ELECTROMAGNETIC RADIATION — Electromagnetic radiation can cause serious personal injury which can be fatal.
c. X-RAY RADIATION—High Voltage tubes can produce dangerous X-rays.

Read the following instructions and take all necessary precautions. ITT, as a component supplier, can assume no responsibility for any damage or injury resulting from the operation of ITT Electron Tubes.

HIGH VOLTAGE

Operating voltages for electron tubes range from about 200 volts to over 150 kilovolts. Since these voltages can be deadly, the equipment must be designed properly and operating precautions must be followed. Design equipment so the operator cannot come in contact with high voltages. Enclose high voltage circuits and terminals and provide interlocking switch circuits to open the primary circuits of the power supply and discharge high voltage condensers whenever access is required.

ELECTROMAGNETIC RADIATION

Exposure of the human body to excess electromagnetic radiation is unsafe. For this reason, the rf energy must be contained properly by waveguides and shielding. Arrangements should be made to prevent exposure of personnel to strong rf fields in the vicinity of electron tubes and in front of antenna systems. (Ref.: Proc. IRE, Vol. 49, No. 2, pp. 427-447, Feb. 1961)

X-RAY RADIATION

Electronic tubes operating at voltages higher than 10 kilovolts produce progressively more dangerous X-ray radiation as the voltage is increased. Therefore, many high power electron tubes are potential X-ray hazards. Provide adequate X-ray shielding on all sides of these tubes, as well as the modulator and pulse transformer tanks. Make periodic checks on the X-ray levels and never operate high voltage tubes without adequate X-ray shielding being in place. (Ref.: "Medical X-ray Protection up to Three Million Volts." National Bureau of Standards Handbook 76. Available from Superintendent of Documents, Washington, D. C. 20402.)