Care instructions
for
industrial electron tube users

Technical Note

Thales Electron Devices
ZI de Vongy – BP 84
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REVISION TABLE

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-	22/11/2011	Jean-Marc LE THUAUT	Creation

DIFFUSION LIST

Name	Service or Company	Name	Service or Company

For Information

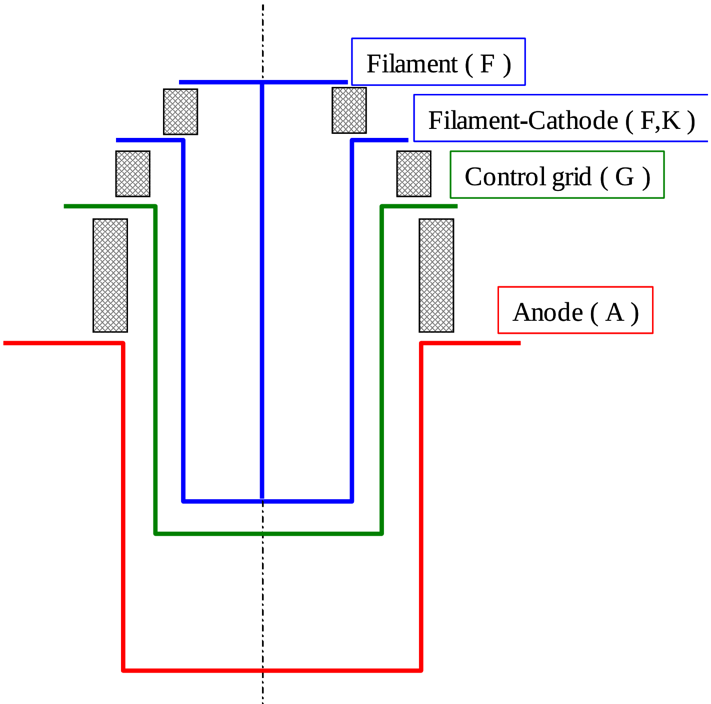
Name	Service or Company	Name	Service or Company

TABLE OF CONTENTS

1. Quick description of industrial electron tubes

Electron tubes are used in high power RF generators for their ability to commute high currents under high voltages. This device is made of 3 or 4 electrodes :

- **1 filament :**
  Source of electrons when heated by application of a given voltage between filament and cathode. Made of carburised thoriated tungsten wires, this part is **very sensitive to shocks and vibrations**.
- **1 or 2 grid(s) :**
  Command electrode which can attract or repulse electrons emitted by the filament, depending of its potential regard to the filament's potential. Made of tungsten, molybdenum or carbon wires, this part is also **very sensitive to shocks and vibrations**.
- **1 anode :**
  Electron collector which is used at high potential in order to attract electrons escaping the grid's barrier. This part is made of copper and is the most appropriated for handling the tube.



scheme of a triode (1 grid)

2. Receiving a new tube

On receipt of the tube, check for any damage which may have occurred during transportation :

- Inspect the inside and the outside of the package for trace of shock or crush,
- Check that the tube has no traces of impact,
- Check the filament continuity and absence of short circuits between the electrodes using an ohmmeter.
- If possible, check the insulation between the electrodes: please refer to our application note *"HV TEST ON GENERATOR TRIODE" (ref.61420096en)*.
  CAPACITOR TESTER MUST NOT BE USED AT THIS PURPOSE

3. Handling a tube

Our packages are designed for an optimum protection of the tube during transportation. So we recommend to keep the tube in its package as long as possible before installing it into a generator.

In order to avoid damages, we recommend to avoid any unnecessary handling, and to prevent the tube from shocks and vibrations.

When removing the tube from its packaging, hold the tube safely by its grid collar or its anode only.

Take care to not touch the ceramic in order to avoid external pollution which could degrade the electrical insulation between the electrodes. The ceramics must be kept clean. Ceramics which have been inadvertently soiled may be cleaned using alcohol or alumina powder but <u>NO ABRASIVE NOR METAL PAD</u>

4. Storage

The tube must be stored in dry, dust-free premises (relative humidity below 70%). Most of the tube references are enveloped in plastic bags with humidity absorbers to contribute to a good storage.

All tubes must be stored in the vertical position in their packaging.

5. Replacing a tube

When replacing a new tube, we recommend to refer to the following checking-list :

- Visual check of the springiness and condition of the contacts and connections.
  - Absence of dust **/** otherwise : clean it.
  - Absence of oxidation on the contacts **/** otherwise : clean it.
  - No destruction of the silver or nickel coatings **/** otherwise : replace it.
  - Absence of soft, broken or melted contact **/** otherwise : replace it.

- Visual check of grid and anode insulators
  - Absence of dust **/** otherwise : clean it.
  - No trace of arc **/** otherwise : replace it.
  - No trace of melting **/** otherwise : replace it.

- Check of the water cooling circuit
  - Good level of the water tank **/** otherwise : fill it.
  - Good resistivity and pH of the water (please refer to the tube's technical specification) **/** otherwise : change the water and DI resin.
  - Clean water tank **/** otherwise : change the water.

- Clean water **/** otherwise : change the water.
- Water flow rate in conformance with the tube's specification **/** otherwise : upgrade and calibrate

❑ Check of the air cooling
  - Absence of dust in the air filters **/** otherwise : clean it.
  - Air flow rate in conformance with the tube's specification **/** otherwise : upgrade and calibrate

❑ Check of the protective devices
  - Overcurrent triggers in proper operation **/** otherwise : replace and calibrate.
  - Low water flow rate trigger in proper operation **/** otherwise : replace and calibrate.

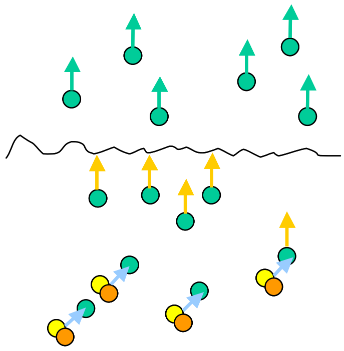
❑ Check of the filament power supply
  - Filament voltage in the range ±2% **/** otherwise : adjust.

6. Lifetime

In addition to the above checking-list, many precautions can be adopted in order to increase the tube's lifetime.

6.1. Management of the filament

The filament is very sensitive to the power applied and its thermal cycles.



A continuous balance between the thorium evaporating and the thorium migrating from the inside of the material to its emitting surface takes place on the surface of the filament. The thorium reacts with the outside layer of tungsten carbide which regulates its migration and makes the filament emission last in time.

$ThO_2 + W_2C \rightarrow 2W + Th + CO_2$

The presence of thorium is needed on the filament surface to provide a good emission.

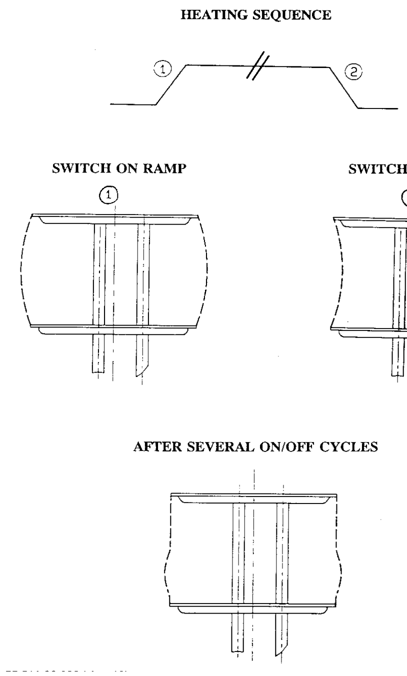
Low filament voltage would result in not supplying enough ThO_2 to the surface and cause a drop of emission.

On the contrary, high filament voltage would result in consuming the W_2C layer too quickly and evaporate all the thorium needed for the emission. <u>Increasing the filament voltage of 5% decreases the life time of 50%.</u>

The filament wires also undergo internal constraints due to the thermal expansions when its applied power varies. When heated at its nominal power, the filament's resistance is about 10 times higher than when cold.

That is why it is highly recommended to not start the filament at its nominal voltage directly : the surge current must be limited to the value given in the tube's technical specification using a ramp voltage or a temporary medium voltage in order to not overheat it or cause too much mechanical constraints.

Besides, filament on/off cycles also affect the mechanical properties of the filament due sagging and fatigue. Under the influence of its own weight and the alternative strength on its wires when switching on and off, residual constraints can remain in the wires and cause deformations as described here on the right.



<u>So we recommend to not exceed more than 2 on/off filament cycle per day</u>.

6.2. Dissipated power and cooling

A special attention should be paid on the powers dissipated in the tube. Maximum values are given in the tube's technical specification.

Approximate values of dissipations can be calculated from the main parameters of RF operation : anode DC voltage (Va), anode DC current (Ia), grid DC current (Ig) and G1 and G2 grid DC voltages (Vg1, Vg2). This calculation can be provided by our customer technical support team on demand.

In the field, the power dissipated in the anode of water cooled tubes can be check by measuring the temperature of the water go in and out of the water jacket :

$P \approx 0{,}07 \, . \, \Delta T \, . \, Q$ With P : dissipated power in kW
ΔT : in/out difference of temperature in °C or °K
Q : Water flow rate in L/min

For air cooled tubes :

$P \approx 0{,}02 \, . \, \Delta T \, . \, Q$ With P : dissipated power in kW
ΔT : in/out difference of temperature in °C or °K
Q : Air flow rate in m^3/min

<u>The temperature on the tube's envelop must not exceed 220°C at any time</u>

6.3. Operating conditions

In a general way, the operating conditions must be checked.

<u>Calculation of operating conditions can be provided by our customer technical support team on demand.</u>

When setting generator, frequencies, voltages and currents must be checked:

- Power off with a variable impedance meter (VIM) for impedances and resonance.
- Power off with a small signal generator and a scope to check resonance and feedbacks.
- Power on with high voltage and high current probes to check voltages, currents and signal frequency.
- Power on with a spectrum analyser in order to seek parasitical frequencies which could cause overvoltages.