General Guidance Notes on the Use of Vacuum Tubes

1. RECEIPT

a) Check shock indicators if fitted on tube. Report to Carrier for provisional transit claim if not intact, check visually for any obvious external damage where shock indicators not fitted.

For customers in Europe we would suggest the tube be returned to e2v technologies if time permits. For others and in the case of a breakdown we suggest the tube be checked as per instructions in Appendix 1 and if OK put into set. Do not tell the carrier that the tube is OK until 500 - 1000 hours have been completed in case it fails prematurely due to transit damage.

2. INSTALLATION

a) Ensure vacuum tube is not knocked or shocked in any way. Tubes are fragile whether they have glass or ceramic envelopes.

b) Ensure all connections to the tube are tight and recheck after a week's operation. In particular, the filament connections take large currents and should be perfect. Water unions should be secure to avoid any leakage, the water circuit should be carefully checked to ensure the flow is in the correct direction and that the flow trips operate. If a thermal fuse is fitted check the filament and HT trip operates. This trip must remove filament supply as well as HT Do not repair thermal fuses because they use special solder and are a cheap disposable item. Overheating on the anode is a major cause of premature tube failure in the field. Temperature stickers can help to highlight problem areas. Check header blower works if fitted.

c) The life of a tube may be optimised by suitable choice of filament voltage. The following advice applies when the incoming supply is stable and unaffected by the operation of other equipment. Extra care is necessary if this is not the case.

i) Industrial: Check filament voltage at the tube if a suitable instrument is available. The instrument should measure true rms voltage. Moving iron and hot wire meters do this, but care should be taken with digital voltmeters unless they specify measuring rms on the AC range. Correct filament voltage is essential to get the best life from a tube. The minimum filament voltage is determined by the operating conditions. The life of a tube is increased by a factor of 2 with every 5% reduction in filament voltage. The reduction possible is determined by the usage of the tube. If it is lightly loaded then the life can be extended further than if it is working at full ratings. A reduction of more than 10% is not recommended because the filament surface may be poisoned. Slumping of power output may indicate that poisoning of the filament is occurring. A small increase, say 5%, on the filament voltage may correct the situation. Check anode and header cooling as well to ensure that the tube envelope is not overheating and creating gassing-up problems.

ii) Broadcast: The guidance in i) should be read, but the following more stringent procedure used.

1. Operate a new tube at the nominal rated filament voltage for the first 200 hours.
2. Reduce the filament voltage in 0.1 V steps and record the output power or distortion levels at each stage, allowing one to two minutes for the emission to stabilise at each reading.
3. When there is a significant drop in the output power or rise in distortion level, stop. Raise the filament voltage 0.2 V above this voltage 'knee'.
4. Check the output or distortion levels in 1 to 2 hours and again in 1 to 2 days to see that they are satisfactory. If they are not satisfactory start at step 1 again.
5. After a period of time it may be necessary to raise the filament voltage to meet the required output or distortion specification. To do this, repeat steps 1 to 5. When the filament voltage required is higher than the nominal rated voltage, the remaining life will be limited and it will be time to order another tube.

3. EQUIPMENT

Depending on the type of cooling some overtemperature trips as well as flow trips may be fitted. The flow trips are best on the outlet side of the cooling circuit. They should be of a failsafe design. These trips should never be bypassed. True flow switches are preferable to pressure switches.

If the anode is air cooled, ensure the air is filtered and keep the filters clean. Preferably the air should flow over the header and then through the radiator to prevent hot air causing overheating of the filament and grid connections.

If water cooling is used it is preferable that demineralised water of low conductivity be used (see notes in Preamble). Normally this is contained in a secondary heat exchanger system, so that only top up quantities of water are needed once the system is working. ***Never top up with mains water.*** Water supplied by garages for car batteries is definitely not suitable since dilute acid is supplied sometimes. The problems with mains water are two fold.

a) high conductivity resulting in excessive corrosion problems.

b) high solids content either dissolved or otherwise resulting in deposits built-up on the anode surface which both prevents efficient cooling of the anode and blocks the tube waterways.

To protect the tube electrically the equipment is normally fitted with fast HT trips i.e. clear faults in a cycle. If Post Office type relays are employed they should not be damped. Additionally, in some types of equipment it is desirable for a grid undercurrent relay to be fitted, so that in the event of the tube failing to oscillate gross anode overloading is avoided. Depending on the tube characteristics, the HT trip will not necessarily operate in the event of the tube not oscillating and hence losing grid bias.

e2v technologies limited, Waterhouse Lane, Chelmsford, Essex CM1 2QU England Telephone: +44 (0)1245 493493 Facsimile: +44 (0)1245 492492
e-mail: enquiries@e2vtechnologies.com Internet: www.e2vtechnologies.com Holding Company: e2v holdings limited

e2v technologies inc. 4 Westchester Plaza, PO Box 1482, Elmsford, NY10523-1482 USA Telephone: (914) 592-6050 Facsimile: (914) 592-5148
e-mail: enquiries@e2vtechnologies.us

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4. WARRANTY

To obtain best cover from spare tubes they should be checked upon receipt and run for up to 200 hours. At this stage, two courses of action are possible.

1. To minimise tube handling the old tube is left as the spare and the new tube run to end of life.
2. The new tube is put into stores as a good spare and the old tube brought back to finish its life. If this is done it is advisable to recheck the spare tube again at 18 months, say, to avoid running out of the normal time warranty of two years. Our experience is that tubes which are OK after 18 months continue to be all right for some years.

   The disadvantage of action 1 is if the tube taken out is very old then its life expectancy is unsure and therefore operational cover is uncertain.

APPENDIX 1 Recommended Test Procedure for tubes above 20 kW output power

Upon receipt the most likely damage to the tube is caused by transit. When shock indicators are fitted these should not be displaced. If they are, a provisional transit damage claim should be filed with the insurers and e2v technologies informed.

It has been found that high voltage oil testing equipment is owned or available to both end users and equipment makers. This equipment gives a voltage output up to 50 kV AC with a power of around 100 VA i.e. 2 mA at full voltage, with a trip current of about 5 mA at lower values. This equipment will not damage tubes and is ideal for checking them. The following safety precautions are mandatory:-

a) Before attempting to adjust or change connections always reduce the test voltage to zero, switch off the high voltage switch and short each high voltage connection to earth using an adequately insulated handle and securely earthed stick.

b) Ensure whilst test is in progress that no other person can approach within 1.2 metres of the tube and pack.

   NB The foam packing material has been found to provide adequate insulation for this type of test, provided it is perfectly dry.

Test 1. Filament to Grid

a) connect anode and grid together
b) Connect leads from tester to filament and grid
c) Increase voltage applied from 0 to 10 kV rms i.e. 14 kV peak

   The tube should stand a minimum of 5 kV, preferably 10 kV. If external flashover occurs from the clips or leads rearrange clips or connections for maximum spacing possible.

Test 2. Grid to Anode

Remove protective paper from ceramic, if fitted.

a) Connect the filament and grid together
b) Connect leads from the tester to grid and anode
c) Increase voltage applied from 0 to 50 kV or until there is an external flashover.

   The tube should withstand a minimum of 30 kV. The tube may condition slightly and withstand a higher voltage with repeated application of the voltage.

Notes

1. Avoid external flashover and corona by eliminating sharp edges and ends to wire, particularly near the ceramic envelope.
2. Under certain atmospheric conditions moisture condenses on the ceramic surfaces causing electrical leakage. If the voltages specified above are not obtainable due to high leakage current, it is recommended that the ceramic surfaces be dried with a warm air blower such as a hairdryer. The tests should be repeated to check whether the leakage current was caused by a moisture film or not.

   The above tests will check for the following faults:-

   Broken Filaments

   The tube will fail test 1 due to internal short circuit and probably will also give a low resistance reading on a multimeter.

   Tube down to air

   Tube will fail tests 1 and 2; in particular test 2 will give 10 kV maximum.

   Tube will not stand full HT operation

   Tube will pass test 1, but only give approximately 25 kV on test 2.

The other hazard from transit is that the filament wires have been cracked by a shock, but not broken. This incipient fault could result in short life and is best tested in the following ways. Either:-

a) Put the tube in the equipment and run for 200 to 500 hours or

b) Put the tube in a unit where minimal water flow can be applied and a filament connection blower is installed. The filament is supplied from the usual transformer, but cycled $^1/_4$ hour on, 1 hour off for 24 hours. (*Note* 1 hour off is necessary to prevent filament distortion). The filament current should be measured at the start and finish preferably with a current transformer to achieve reasonable accuracy. No drop in current should be noted. If a drop does occur then the test should be continued for a further 24 hours to check the current remains constant. A further drop would indicate that the filament was breaking up and transit damage had occurred. Drops of 1% should give cause for concern.

   The remaining problems with tubes after initial testing are storage and checking the tube after a period. Here we used to recommend that the tube be run in the equipment every six months. However, this put the tubes at risk due to the chance of mishandling. We now suggest that the tests 1) and 2) should be adequate because the only reason a tube should fail after storage is due to leakage of air which is detected by these tests especially if the figures are different to the initial test values. The storage check should be undertaken either every 6 months or say after 18 months i.e. before the tube warranty runs out. Should the tube be satisfactory after this period then it is certainly a good spare for a further 3 to 5 years.