This note describes some protective devices to prevent the tube from being damaged in case of malfunction.

Guarantee claims can only be asserted if these safety devices have been provided.

1) Protection against high voltage sparkover (Test Wire Method)

To protect the tube from damage in case of sparkover a high-speed trip circuit is required, which disconnects the anode voltage and limits the energy released during arcing. By means of a simple test wire method it can be checked whether the tube is sufficiently protected. For this purpose the connected anode voltage is short-circuited by a copper wire with given diameter (see table) which is directly applied at the tube supply lines. If the wire does not fuse, the trip circuit complies with the requirements.

Type	I^2t ($A^2.s$)	Test wire diameter (mm)
RS 3005 CL, CJ	140	0.22
RS 3010 CL, CJ	500	0.30
RS 3011 CL, CJ	500	0.30
RS 3012 CL	500	0.30
RS 3020 CL, CJ	500	0.30
RS 3021 CL ,CJ	500	0.30
RS 3026 CL, CJ	900	0.35
RS 3027 CL, CJ	900	0.35
RS 3040 CL, CJ	900	0.35
RS 3041 CL, CJ	900	0.35
RS 3060 CL, CJ	1500	0.40
RS 3060 CJC	500	0.30
RS 3061 CJ	900	0.35
RS 3150 CJ	900	0.35
RS 2041 J	500	0.30
RS 3300 CJ	1500	0.40
RS 3500 CJ	2400	0.45
RS 3700 CJ	2400	0.45

Type	I^2t ($A^2.s$)	Test wire diameter (mm)
ITK2-1, ITL2-1	240	0.25
ITK3-1, ITL3-1	240	0.25
ITK5-1, ITL5-1	240	0.25
ITL9-1	240	0.25
ITK12-1, ITL12-1	240	0.25
ITK15-2, ITL15-2	240	0.25
ITK25-1, ITL25-3	240	0.25
ITK30-2, ITL30-2	1500	0.40
ITK60-2	1500	0.40
ITK70-2	240	0.25
ITK90-1	240	0.25
ITK120-2, ITK120-3	1500	0.40
ITK200-1, ITK200-3	1500	0.40
IQK12-1, IQL12-1	240	0.25
IQK25-1	240	0.25
IQK35-1, IQK35-2	1500	0.4

Table : Copper wire diameters for checking the high-speed trip circuit

By means of the I²t value, which is additionally given in the table, compliance with the test wire requirements can also be checked mathematically, provided that the behavior of the short-circuit current in time is known or can be estimated. The integral $\int I^2 dt$ as a function of the time during which the short-circuit current is flowing through the tube must not exceed the tabulated I²t value.
The protective measures to be taken depend on the kind of anode power supply used and on its performance.

If the anode voltage transformer is series-connected with a thyristor controller, the latter should also be utilized to rapidly disconnect the anode current from the line. The disconnecting time achieved with this method is short enough.

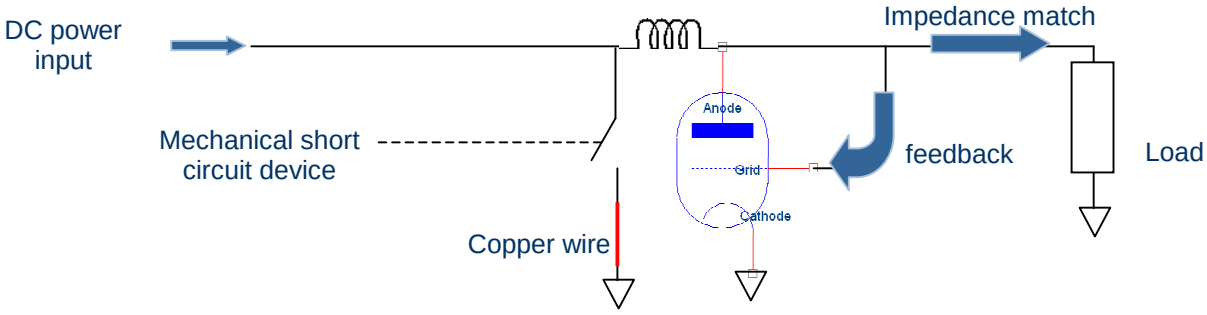

Figure: Principle of the high-speed trip circuit test

In other cases, a sufficiently high internal resistance of the rectifier may be useful (transformer leakage not too low, equivalent series resistance, if necessary).
Generator power supplies of medium or low power usually meet the test wire condition without requiring additional measures, since the I²t values permissible for THALES tubes are relatively high.

High-power generators can either be protected by “crowbar” circuits or GTO/IGBT thyristors. Crowbar circuits – known from radio transmitters – use an ignitron as short-circuiting device, which is connected in parallel of the rectifier output. GTO/IGBT thyristors are employed as interrupters in the anode DC path also ensure efficient high-speed tripping.

The anode voltage may only be reconnected after a recovery time of at least 100 ms.

2) Protection against grid overvoltages

To protect the grid against overvoltages resulting from switching voltage peaks or interference wave excitation, it is often necessary to provide a sphere gap of 1 to 2 mm (approx. 10 mm sphere diameter) between grid and cathode terminal and as close to the tube as possible.

3) Protection of the grid polarization circuit from harmonics

Under the same aspect a sufficiently capacitive wiring of the grid-cathode path is important for the harmonic short circuit at the grid. However, the total capacitance effective between grid and cathode should not exceed a circuitry-dependent maximum value, since above this maximum intermittent oscillation will occur (blocking oscillator effect).

4) Protection against grid overcurrent

For generators with varying load resistance, the use of nonlinear resistors (e.g. incandescent lamps) in the grid circuit is recommended in order to avoid impermissible grid loads.

5) Air-cooled tube protection against anode overdissipation

To protect the anode of air-cooled tubes against thermal overloading, tube fuses have been developed which, connected to a pull switch, cut off anode voltage and heater. The individual data sheets specify the tube fuse to be used.

Independent of using these tube fuses the protection against thermal anode overloading have to be observed (automatic monitoring of coolant quantity and temperature).