

1.0 Problem Reported by Customer

From email dated 05-MAY-08: "Days ago we noticed that the generator did not sustain for more than a few minutes a power level of 500W. To-day again, at 500W, with a matched load (reflected power 20 W), the generator went off again, apparently switched off by the temperature sensor. Notice that air temperature in the lab was around 17°C."

From email dated 08-MAY-08: "Comparing with filament of the spare magnetron we bought from you, shows that indeed filament is open."

No failures of waveguide components were reported.

2.0 Description of Customer Equipment Configuration

None provided other than as indicated above. The microwave generator was delivered along with a 3-port circulator (model GA1108) and dummy load (model GA1221) which are typically used in an isolator configuration to protect the magnetron from reverse power.

3.0 Results of Inspection and Testing

The magnetron filament resistance was measured and found to be infinite, thus indicating an open circuit. Resistance between the anode and either filament lead was also found to be infinite for both.

Evidence of arcing inside waveguide at the magnetron antenna (photo 1). Vacuum seal broken at antenna (photo 2). No evidence of arcing along the length of the waveguide.

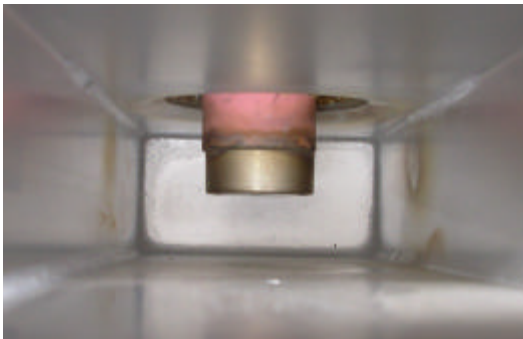


Photo 1



Photo 2

The magnetron was disassembled and internally inspected. Heavy oxidation was found on the anode vanes and straps (photos 3 and 4). No deformation of the anode or antenna structures was found.

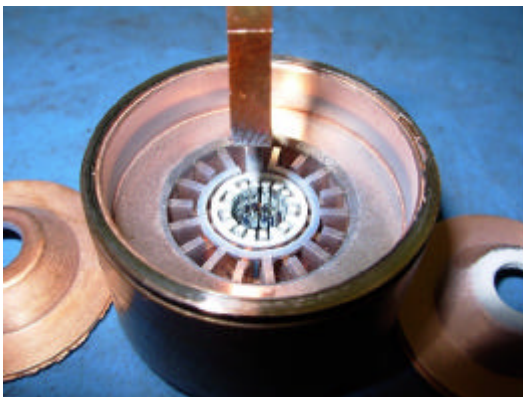


Photo 3



Photo 4

Heavy oxidation was also found on the filament, as well as evidence of the open filament wire (photo 5). The filament wire is otherwise fully intact and shows no other indication of deformation.



Photo 5

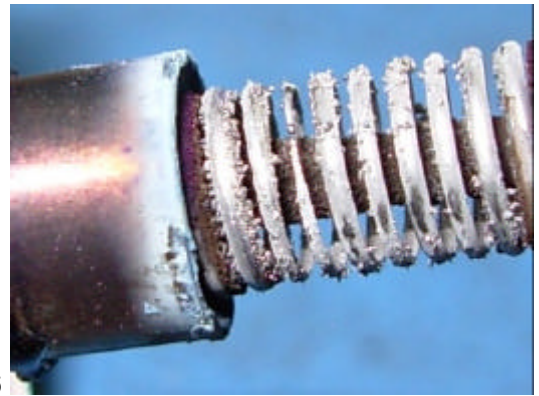


Photo 6

4.0 Analysis and Conclusions

Arcing between the antenna and waveguide can only be caused by an excessively high electric field at the magnetron antenna. The only possible causes are a high level of reverse power (high VSWR) or an arc that originated somewhere down the waveguide which would then have traveled to the magnetron antenna (arcing in waveguide always tends to travel toward the magnetron). Once established between the antenna and waveguide, arcing would have been sustained as long as microwave power was being generated.

The sustained arcing eventually caused failure of the vacuum seal between the ceramic antenna body and metal cap. The sudden inrush of air (oxygen) inside the magnetron body while the filament and anode were at full operating temperature allowed rapid oxidation of the heated metal surfaces. Since the filament voltage was still being applied, the filament quickly overheated until melting and thus creating the open circuit.

Since there is no evidence of arcing along the length of the waveguide, our conclusion is that magnetron failure occurred due to high reverse power (high VSWR) at the magnetron antenna.

5.0 Recommendations

The microwave generator in which this magnetron was used should never be operated without the use of a 2-port waveguide isolator (or 3-port circulator and dummy load) to protect the magnetron from reverse power. Since a circulator and dummy load were delivered along with the generator, it is presumed these components were installed in a system configuration for magnetron protection as described in the respective product user manuals that were delivered with the equipment. However, it is possible that protection may have been compromised if water flow in the dummy load was not provided according to instructions. The use of a water flow interlock device can help prevent damage due to lack of water flow.