Insights and best practice

AMPLIFIER KNOW-HOW

TECHNICAL NOTE 0101

TWT AMPLIFIER - FITNESS PLAN

The challenge

A TWT amplifier is a big investment which you will expect to serve your needs for many years. TWT is a proven technology which has been employed in High Power Amplifiers for many decades, and today's designs are more robust than ever, capitalizing on extended performance and high levels of reliability.

Like other high-performance systems, you can extend or shorten the operational life of a TWTA by simply adjusting the processes and procedures in place for their general use.

Double *or* ***triple*** *the useful life of a TWT Amplifier.*

The solution

The TWT Amplifier Fitness Plan has been engineered to help users get consistent long-term performance from their instrument. Following this plan will ensure you provide the greatest protection for the specialized components contained in a TWT design. The plan has been developed by our design and engineering teams who have seen first-hand the problems that can be caused by inconsistent operating procedures.

The Fitness Plan contains the operational do's and don'ts that will ensure you get the maximum return on your investment and many years of trouble-free service.

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AMETEK®
COMPLIANCE TEST SOLUTIONS

INTRODUCTION

Double or **triple**
the useful life of a
TWT Amplifier.

Care and Feeding of TWT Amplifiers

A contributing cause of failures of Traveling Wave Tube Amplifiers (TWTA's) is the improper care of the Traveling Wave Tube (TWT) by the end user. TWT's are designed and meant to operate at a maximum temperature range. It is, therefore, important these parameters be considered in order to obtain maximum performance and a high MTBF (Mean Time between Failures) of the TWTA. These considerations are taken into account with the system amplifier design.

A major consideration when using TWTA's is to ensure the cooling system is operating as designed by the manufacturer. For air-cooled units, there should always be a free flow of air at both the inlet and exhaust ports of the cooling system. For liquid-cooled units, the coolant level flow rate, as well as the inlet and outlet temperatures, should be checked routinely and should fall within the manufacturer's recommended specifications. If these factors are considered, the first step has been taken to a long and trouble-free life for your TWTA.

To better understand the importance of a well-maintained cooling system, consider the following:

During the manufacturing process, TWT's are thermally aged and pumped down (evacuated) for long periods of time, at high temperatures, and with high voltages applied to the 'active elements' (cathode, collector, anode, etc.). The purpose of this aging cycle is to outgas the oxides from the vacuum envelope. (These oxides are by-products of the metallic elements when struck by the electron beam.) The removal of these oxides from the vacuum envelope is done by a continuous pumping process (exhaust) of the air within the vacuum envelope over hot and cold thermal cycling. Generally, it is these foreign gases in the vacuum envelope which cause arcing and overheating, leading to loss of efficiency of the TWT, and ultimately a failure.

When TWT's are not operated within their designed temperature parameters, the electron beam can become defocused. This defocusing can cause the electron beam to strike a different area of the collector surface and result in outgassing of the metallic element. The outgassing (generating contaminates) within the vacuum envelope can result in arcing within the TWT and, over time, may cause the TWT to fail.

Over a period of time, we have analyzed this mode of failure and concluded, by following certain procedures, it can be minimized. The recommended procedure allows the TWT Amplifier to thermally stabilize prior to applying high voltage, and to periodically cycle the TWTA to burn-off gas when the unit has not been used over a period of time. This recommended procedure is as follows:

TWT AMPLIFIER FITNESS PLAN

1	Prior to applying AC Prime power, verify that the proper AC voltage and phase sequence are available (if phase sensitive), and either 1) the proper RF Components are connected or 2) that both the RF Input and Output are properly terminated into 50 Ohm terminations.
2	Apply AC Prime Power (AC Circuit Breaker ON). Verify that the air flow path or cooling system is unrestricted and liquid cooling levels are per the manufacturer's specifications.
3	Switch the unit from "DC Power Off" to "DC Power On". Observe that the proper indicator and function lamps are illuminated and that a "Fault" has not occurred. Allow the unit to time out to "Standby" mode prior to proceeding to Step 4.
4	If the unit has been stored for a period of time, allow the unit to operate in the "Standby" mode for approximately 15 to 30 minutes before switching to the "Operate" 'mode. The normal thermal stability period for the TWT is approximately 20 minutes in the "Standby" Mode.
5	When the unit is thermally stabilized as described in 4 above, again verify that the RF Input is properly terminated into an RF Load or signal source, and that the RF Outputs are terminated into a dummy load or antenna which meets the minimum RF VSWR specifications as described by the manufacturer.
6	After Step 5 has been completed, switch the system to the "Operate" mode and verify the panel meter indicators (voltage/current) are within the manufacturer's specification. Slowly apply RF Input Power to within the manufacturer's specification to obtain rated output power. Note: When switching the unit to the "RF/OFF" mode or changing frequencies, it is always a good practice to reduce the RF Input Drive by at least 20 dB. This is to avoid over driving the TWT, which may result in a helix or VSWR Trip.
7	If the TWT indicates a helix or solenoid fault, gas may be present in the vacuum envelope of the TWT. This is typical in high power TWT's which have been stored or unused for an extended period of time. If a fault occurs, depress the "Fault reset" button and allow the TWTA to operate in the "Stand by" mode for 30 minutes before switching to "RF On" mode again.

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When testing is completed, it is recommended for the operator to allow the TWTA and the external cooler to cool down to the ambient operating temperature prior to turning the AC/DC Power Off. This typically takes about 5-10 minutes of operation in the “Standby” mode.

It is a good practice to allow the TWTA to cool with the aid of its internal cooling system. Otherwise the TWT could be susceptible to external gases migrating into the RF vacuum envelope, which can result in arcing and premature failure of the TWT. In addition, it is recommended the above turn-on sequence be done as periodic maintenance of TWTA’s in the following:

a) 10 to 50 Watt TWTA’s, Traveling Wave Tube Amplifiers:

Each month operate the TWTA in “Standby” mode for 30 minutes and ‘in the “RF On” mode for an additional 30 minutes. Verify that the RF input and output are properly terminated into 50 Ohms.

Allow the unit to cool down in the “Stand by” prior to turning the unit to the “OFF” position. It is a good practice to record the Panel meters readings periodically for future reference.

b) 100 to 500 Watt TWTA’s. Traveling Wave Tube Amplifiers:

Depending on the external environment, TWTA/TWT’s which are non-functional for 3 to 4 weeks should follow the turn on sequence stated below to outgas the TWT and cycle the power supply. Allow the TWTA to operate in the “Standby” mode for 30 minutes prior to switching to the “RF On” mode. While in the “RF ON” mode, allow the TWTA to operate for approximately 30 minutes. The TWTA should also be properly terminated (RF Input and Output) into 50 Ohm loads and then follow the turn “OFF” sequence stated above allowing the Unit to cool to ambient temperatures slowly.

The RF performance should be verified and tested and the meter readings should be recorded so that these manufacturers’ normal indications are maintained for reference.

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c) 1.0 to 10.0 kW TWTA’s, Traveling Wave Tube Amplifiers:

These TWTA’s typically require considerably higher voltages and cooling- capabilities, and sometimes can be liquid-cooled. The overall TWT structure is larger thus making it more susceptible to having outside gasses enter the RF vacuum envelope. For best performance, the TWTA should be thermally stabilized in the “Standby” mode for 30 minutes and operated for 30 to 60 minutes in the “RF On” mode at least every 3 to 4 weeks. During the normal turn-on sequence, the various panel voltages and currents should be monitored for proper operation. For those units which utilize an external liquid cooler, the coolant level, flow rate, temperature and pressure should also be monitored.

As stated earlier, the RF input and outputs must be properly terminated and the proper cool down sequence followed. It is also a good practice to log the readings of both the amplifier and cooling system (if applicable) panel meters and document whether there has been any changes each time the system is rated.

CONCLUSION

The procedures detailed above may seem a bit overkill, but TWT's, by nature of their structure, are susceptible to outgassing and vacuum leaks, which could result in a shorter than typical MTBF. Regular operation of the TWTA system is the best way to insure the longevity of the amplifier.

Past history has proven, by following the simple steps listed in the Fitness Plan the MTBF can be improved greatly. With periodic cycling, the internal arcing is minimized, therefore, minimizing carbon build-up of the TWT. This carbon build up is the main cause of failure of the TWT's and the resulting arcing associated with power supply failures. This action, coupled with proper thermal stabilization techniques, will double or triple the useful life of a TWT Amplifier.

In conclusion, our fundamental approach is to focus on properly cooling the TWT and Power Supply. By doing so and adopting the TWT Amplifier Fitness Plan, you will ensure all users fully understand the importance of the correct usage of the TWTA and the impact it has on the longevity and performance of your investment.

ANY QUESTIONS?

If you have any questions on this, or any other topic please send them to:
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