



Periodic Klystron Maintenance

If satcom Klystrons are to be stored for extended periods, it is recommended that they be periodically checked for vacuum integrity. This can be achieved in a number of ways:

- Installation into a KPA system.
- Use of the CPI Klystron Test Set.
- Using a hi-pot high voltage (10kV), low current power supply.

It is recommended that this check be done after six months in storage, and then annually after that.

Given the continual advances in klystron manufacturing technology and materials, CPI no longer believes that it is necessary to perform six-monthly conditioning at full beam voltage.

WARNING

SAFETY FIRST! Test voltages are potentially lethal. Before attempting to verify vacuum integrity of your klystron, ensure that all safety precautions are taken. Personnel performing this operation must have sufficient understanding, training and experience to perform it safely. All operations must be performed in accordance with the operating instruction for the equipment being used.

Verification of vacuum integrity

Klystrons are manufactured using high quality materials and assembly techniques, and while it is unlikely that vacuum integrity could be compromised under the normal use or storage, CPI recommends verifying vacuum integrity periodically. A poor vacuum in a klystron will cause breakdown between cathode and body. Depending on the internal pressure, the breakdown voltage can be anywhere from 200V up to about 8.5kV. The higher figure represents a C-band klystron that is at atmospheric pressure. Other effects of loss of vacuum are inhibited beam current (as the cathode is chemically poisoned), and increased heater current (due to changes in heat loss mechanisms, and changes of resistivity of tungsten with temperature). The CPI Klystron Test Set operates at a maximum voltage of 1kV, and so proper use of this set depends on assessing heater current and beam current, see the operating instructions.

Using the Klystron Test Set

The instruction manual for the Klystron Test Set describes a Performance Test to determine the Perveance (the relationship between beam voltage and beam current) which confirms that the klystron vacuum is intact by verifying cathode emission performance. In the case of an MSDC klystron, a special connector is required to connect collector 1 to ground, and to allow collectors 2 and 3 to float. The electrodes must be properly discharged after the test. Consult CPI to obtain the required connector if you are working with an MSDC klystron.

Using a Hi-Pot tester

Using a Hi-Pot tester is similar in concept to using a KPA, described below. There are additional safety considerations due to the nature of the equipment. In the case of an MSDC klystron, a special connector is required to connect collector 1 to ground, and to allow collectors 2 and 3 to float. The electrodes must be properly discharged after the test. Consult CPI to obtain the required connector if you are working with an MSDC klystron.

1. Connect the heater and cathode leads of the klystron to each other. In the case of MSDC devices, this is achieved in the same connector as is used to connect the collectors together.
2. Take all possible precautions to ensure that the Hi-Pot test unit is not energized, and is fully discharged.
3. Connect the cathode leads to the negative terminal of the power supply.
4. Connect the body of the klystron to the groundside of the power supply.
5. Before switching on, take steps to ensure that personnel cannot touch the high voltage terminals when voltage is applied.
6. To verify vacuum integrity, apply high voltage to the cathode and raise it gradually. There may be bursts of current as voltage is raised. The final level depends on the klystron type:
 - a. C-band (klystron models operating in the range 5.7GHz- 7.2GHz): 8.5kV.
 - b. Ku and DBS (12.75 GHz – 18.4GHz) : 6.5kV.If current drawn at this voltage is negligible (less than 0.2mA) then vacuum integrity is intact.
7. Remember to turn off and discharge the equipment (and floating MSDC collectors) safely before touching connections.

Using a KPA

1. Connect the klystron into the KPA as per the operating instructions. The input and output microwave connectors should be terminated with loads or attached to the amplifier input and output assemblies.
 2. Do not apply heater voltage, if possible. If your KPA does not allow this mode of operation, see below.
 3. To verify vacuum integrity, apply the lowest available beam voltage to the cathode and raise it gradually to 10kV. If no current is drawn, vacuum integrity is intact.
- Depending on the KPA model, it may be difficult to apply beam voltage with no heater voltage. On other KPA's, it may be difficult to control the beam voltage. In these cases, it might be easier to run the klystron at full beam voltage, see the section on "Running Up After a Period of Prolonged Storage" below.

Running Up After a Period of Prolonged Storage

- Apply heater power in the usual manner. Allow the klystron to warm up for between five and fifteen minutes. Do not leave it for longer than fifteen minutes before applying high voltage.
- When applying high voltage, start from the lowest value possible.
- Set body current trip level to 20mA, as a precaution, while running up.
- There may be intermittent bursts of body current as gas is cleared. This should clear fairly quickly, so that full operating voltage is reached in a few minutes.
- Once full beam voltage is attained, RF may be applied. The klystron should be run both with and without RF input for a minimum of a half hour after the beam current has been seen to stabilize.
- The time to stabilize will vary with the age of the klystron, storage time, storage conditions, etc.

Operation

Once the klystron is in service, it is extremely important to operate the klystron correctly with adequate maintenance. In achieving this, three items should be stressed:

- i) Stand-by mode should be with beam switched on, preferably at the lowest beam voltage necessary to achieve the required performance. Leaving the klystron on stand-by with filament on but beam off, for extended periods (days rather than hours), can cause damage to the cathode, resulting in premature failure of the klystron.
- ii) It is most important that the collector cooler is kept clean. If the cooler becomes clogged, the collector can become overheated. Over a sustained period, gas can evolve causing damage to the cathode. Maintenance of cooling air filters is similarly important.
- iii) The filament should always be operated at the nameplate voltage for a particular klystron. Operating the filament too high or too low can cause premature klystron failure. When the klystron is old, and the beam current drops due to cathode depletion, the filament voltage can be raised 0.5V without causing any harm. This will temporarily extend the life of the klystron for a short period of time until a replacement klystron can be obtained. There is, however, no guarantee as to the period of extended klystron life, if any, as this does vary from klystron to klystron dependent on the condition of the cathode.

Stand-By Klystron Operation

The following table details the recommended mode of operation for klystrons used in stand-by operation. This tends to occur when an amplifier is used in a 1:n configuration but can also occur if an amplifier is being used to carry very occasional traffic and an operator may want to save power during the "off air" period. The table starts with the most desirable mode of operation and flows down to the least desirable. The most desirable mode will provide best klystron life and the least desirable will result in worst klystron life.

Tube Life	Filament Power	Beam Power	RF Power
Best	Off	Off	Off
	On	Reduced ¹	On
	On	Reduced ¹	Off
	On	Full	On ²
	On	Full	Off
	Reduced ³	Off	-
Worst	Full	Off	-

Notes:

1. Assumes beam power reduced by at least 1 kW.
2. Assumes RF output power is at least 1 kW.
3. Most modern KPAs automatically reduce filament power when in this mode.

This document is not designed to replace safety, operational and maintenance instructions given in the amplifier operations manual and should only be used to supplement information given. For a complete guide of this information, please consult your operating instructions.