350MHz KLYSTRON SPOTKNOCKING TECHNICAL NOTE

THIS TECHINICAL NOTE DESCRIBES THE KLYSTRON SPOTKNOCKING PROCESS AND OPERATION OF THE SPOTKNOCKING POWER SUPPLY

The term “spotknocking” refers to the process of high-voltage dc conditioning of the 350MHz klystrons in use at APS. The name was derived from the conditioning process whereby field-emitting “spots” on elements of the klystron gun are “knocked” off or removed by a low-energy high-voltage arc without causing damage to the klystron. The Spotknocking Power Supply is current and voltage regulated, and is designed to have low stored energy so that any arc across the power supply output will be limited to a maximum energy of 20 joules. It provides a variable voltage output from 0-125kV dc, at a maximum current of 10mA.

The Spotknocking Power Supply system is manufactured by F.u.G. Electronik and consists of four parts (see figure 1), the power supply unit, the high-voltage connection box, the high-voltage cable set, and the 480volt/3-wire extension cord. The high-voltage cable set consists of four cables that are terminated with a long F.u.G. connector on one end and a standard PANTAK connector on the other, and one cable with F.u.G connectors on both ends. The F.u.G.-F.u.G. cable is used to connect the output of the power supply to the high-voltage connecting box, and the F.u.G.-PANTAK cables are used to connect from the high-voltage connecting box to the klystron under test. The use of this cable set results in a test system with no exposed high-voltage connections.

Operation and use of the spotknocking power supply is straightforward and should be undertaken observing standard high-voltage safety principles and practices.

NOTE: Any klystron being spotknocked must have a minimum of 20 minutes cool-down time for the cathode (filament power off) prior to applying voltage from the spotknocker. One hour of cool-down time is required for precision gun leakage measurements.

NOTE: Any klystron being spotknocked must be inside a closed klystron garage, as the spotknocking process can cause the klystron to produce x-rays!

GENERAL INSTRUCTIONS FOR KLYSTRON SPOTKNOCKING USING THE F.u.G. SPOTKNOCKING POWER SUPPLY:

The following steps describe the correct method for spotknocking EEV and Thales klystrons while they are installed in RF1-RF5:

1. Shut down and LOTO the rf system, with every person taking part in the spotknocking procedure performing LOTO.

   NOTE: Refer to Procedure #3104-00032, "Lockout/Tagout Procedures for the Synchrotron and Storage Ring RF Power Supplies" for detailed information while performing step 1.

   NOTE: Remove the padlocks from the klystron PANTAK cable hasps before capturing the power supply control key in the LOTO process.

   NOTE: When spotknocking EEV klystrons, it will be necessary to open the klystron garage to gain access to the klystron PANTAK connectors.

2. Remove the PANTAK cables from the klystron and discharge them to ground using the anode tank shorting stick. Wrap the plugs in clean rags to avoid contamination of the connectors, and place them on top of the mod-anode tank.

3. Position the spotknocking power supply and high-voltage connecting box at the gun-end of the klystron.

4. Connect the ground wire clip the spotknocker high-voltage box to the rf power supply ground system (see figure 2).

5. Thoroughly clean and grease three spotknocker PANTAK connectors (see figure 3). Also, inspect and clean the klystron PANTAK sockets before inserting the spotknocker connectors.

   NOTE: Any contamination or damage in the klystron PANTAK sockets can cause immediate damage to the spotknocker cables when high voltage is applied!

6. Insert any three spotknocker PANTAK cables into the klystron PANTAK sockets (see figure 4).

NOTE: All five sockets of the F.u.G. spotknocker high-voltage connecting box are wired in parallel, so any PANTAK cable can go to any klystron PANTAK socket.

NOTE: It is not necessary to cover the unused F.u.G socket on top of the high-voltage connecting box. Access to the connecting box will be restricted during the spotknocking process.

7. Connect the high-voltage connecting box to the main Spotknocker power supply chassis, utilizing the F.u.G-to-F.u.G high-voltage cable (see figures 5-7).

   NOTE: Wipe the F.u.G. connectors with a clean dry rag before inserting them into their mating sockets. DO NOT APPLY GREASE TO THE CONNECTORS!

   NOTE: Make sure that the ground connection on the back of the power supply unit is secure! (see figure 8)

8. Connect the 480v/3-ph power cord up to a switched receptacle, utilizing the 3-phase extension cord if necessary.

   NOTE: There are three 480v/3-ph "welding" outlets in Building 420 available for this purpose, two on the outside wall behind the rf stations, and one located by the door leading to the Sector 36 Zone-F access door. One of these outlets can be reached from any rf station, using the extension cord if necessary.

9. Double-check all ground connections, particularly the ground clip between the high-voltage connecting box and the rf system ground.

10. Clear all personnel from the area of the high-voltage connecting box and cables, and close the 480v disconnect switch (see figure 9).

You are now ready to perform the first of two spotknocking procedures on the klystron. The first test is the *anode-body ceramic leakage test*, which is outlined in figure 10. This test involves the application of high voltage across the mod-anode-to-body ceramic. During this test, the spotknocking power supply output voltage will be increased slowly, while observing the output current value. The output current will consist of a constant dc leakage across the ceramic, with

occasional bursts of current that are caused by internal arcing and point-discharges between the internal elements of the klystron gun. Sudden spikes in the klystron vacuum usually accompany these bursts of current. Eventually the gun components will condition to the high-voltage and the arcing should cease, with only the static leakage current remaining.

The normal value for static leakage current across the anode-to-body ceramic is approximately 100-250µA @ 80kV.

NOTE: At no time during the conditioning process should the maximum average power out of the spotknocking power supply exceed 200 watts!

Power levels higher than this can crack the gun ceramics due to non-symmetric heating. A crack in gun ceramics will result in loss of klystron vacuum!

NOTE: If severe internal arcing is encountered, remove the high voltage from the klystron!

NOTE: It is possible to hear the internal arcing of the klystron, with the sound being a clearly audible snapping sound identical to what is heard with high-voltage discharges in air.

11. Set the voltage control of the spotknocking power supply to zero (see figure 11).

12. Energize the 480v main switch of the spotknocking power supply (see figure 12). All three green phase voltage indicator lamps should be illuminated at this point.

13. Turn on the spotknocking power supply by closing the control power switch (see figure 13).

14. Set the current control of the spotknocking power supply to 2mA (see figure 14).

15. Slowly increase the output voltage of the spotknocking power supply and record the voltage and current output data (see figure 15).

    *NOTE: If the current across the klystron ceramic is higher than normal, it may be necessary to increase the current limit of the spotknocking power supply higher than 2mA****. DO NOT EXCEED 200 WATTS AVERAGE DISSIPATION ON THE CERAMIC!***

16. At the completion of the mod-anode-to-body leakage test, reduce the output voltage of the spotknocking power supply to zero. Shut down the supply by opening the control power and 480v main switches on the front panel of the spotknocking power supply, and also opening the 480v/3-ph fused disconnect switch.

17. Disconnect the 3-wire power cord from the disconnect switch socket and stow the connector near the spotknocking power supply.

18. Disconnect the high-voltage connecting cable from the output of the spotknocking power supply and short it to the high-voltage connecting box ground.

19. Disconnect the spotknocking PANTAK cable running to the klystron mod-anode at the high-voltage connecting box, and discharge the F.u.G connector tip to the high-voltage connecting box ground. Then, disconnect the other end of this cable from the klystron and stow the cable out of the way.

20. Insert a standard PANTAK-to-PANTAK high-voltage cable into the klystron mod-anode and connect the other end of this cable to the rf system ground (see figures 16 and 17).

21. Connect the high-voltage connecting box to the main Spotknocker power supply chassis, utilizing the F.u.G-to-F.u.G high-voltage cable (see figures 5-7).

NOTE: Make sure that the ground connection on the back of the power supply unit is secure! (see figure 8)

NOTE: Wipe the F.u.G. connectors with a clean dry rag before inserting them into their mating sockets. DO NOT APPLY GREASE TO THE CONNECTORS!

22. Connect the 480v/3-ph power cord up to a switched receptacle, utilizing the 3-phase extension cord if necessary.

NOTE: There are three 480v/3-ph "welding" outlets in Building 420 available for this purpose, two on the outside wall behind the rf stations, and one located by the door leading to the Sector 36 Zone-F access door. One of these outlets can be reached from any rf station, using the extension cord if necessary.

23. Double-check all ground connections, particularly the ground clip between the high-voltage connecting box and the rf system ground.

24. Clear all personnel from the area of the high-voltage connecting box and cables, and close the 480v disconnect switch (see figure 9).

You are now ready to perform the second spotknocking procedure on the klystron. This test is the *cathode-anode ceramic leakage test*, which is outlined in figure 18. The process and characteristics of this test are identical to the anode-body ceramic leakage test. *The normal value for static leakage across the anode-body ceramic is approximately 100-500µA @ 65-80kV.*

NOTE: At no time during the conditioning process should the maximum average power out of the spotknocking power supply exceed 200 watts!

Power levels higher than this can crack the gun ceramics due to non-symmetric heating. A crack in gun ceramics will result in loss of klystron vacuum!

NOTE: If severe internal arcing is encountered, remove the high voltage from the klystron!

NOTE: It is possible to hear the internal arcing of the klystron, with the sound being a clearly audible snapping sound identical to what is heard with high-voltage discharges in air.

25. Set the voltage control of the spotknocking power supply to zero (see figure 11).

26. Energize the 480v main switch of the spotknocking power supply (see figure 12). All three green phase voltage indicator lamps should be illuminated at this point.

27. Turn on the spotknocking power supply by closing the control power switch (see figure 13).

28. Set the current control of the spotknocking power supply to 2mA (see figure 14).

29. Slowly increase the output voltage of the spotknocking power supply and record the voltage and current output data (see figure 15).

*NOTE: If the current across the klystron ceramic is higher than normal, it may be necessary to increase the current limit of the spotknocking power supply higher than 2mA**. DO NOT EXCEED 200 WATTS AVERAGE DISSIPATION ON THE CERAMIC!***

30. At the completion of the cathode-anode ceramic leakage test, reduce the output voltage of the spotknocking power supply to zero. Shut down the supply by opening the control power and 480v main switches on the front panel of the power supply, and also opening the 480v/3-ph fused disconnect switch.

31. Disconnect the 480v/3-wire power cable from the 480volt source and the spotknocking power supply.

32. Disconnect the high-voltage connecting cable from the output of the spotknocking power supply and short it to the high-voltage connecting box ground.

33. Remove all PANTAK cables from the klystron, discharging each cable to the high-voltage connecting box ground stick.

34. Thoroughly clean all of the spotknocker system PANTAK connectors with ethyl alcohol to remove any traces of insulating oil from the rubber components of the connectors. When clean, wrap the connectors in clean, dry rags secured with cable ties.

NOTE: Any Diala or similar hydrocarbon insulating oil left on the PANTAK connectors will cause swelling of the rubber component of the connectors, eventually making them impossible to insert into a socket.

Make sure the connectors are clean! These cables cost $4,000 each!

35. Re-connect the rf power supply PANTAK connectors to the klystron, and resume system operation.

36. Place the spotknocking power supply system back in storage.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

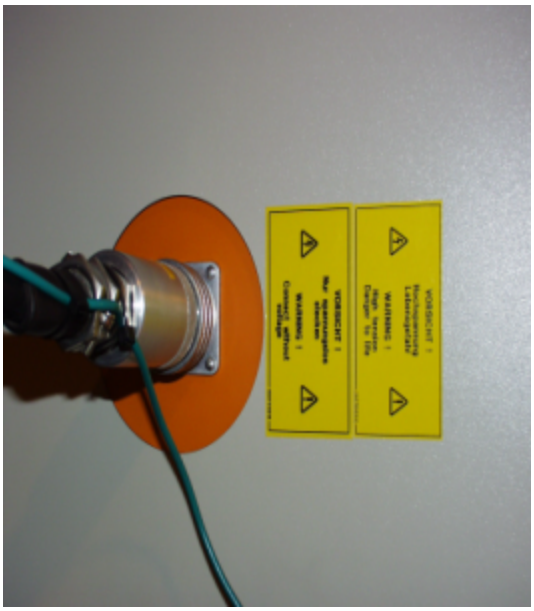

Figure 6

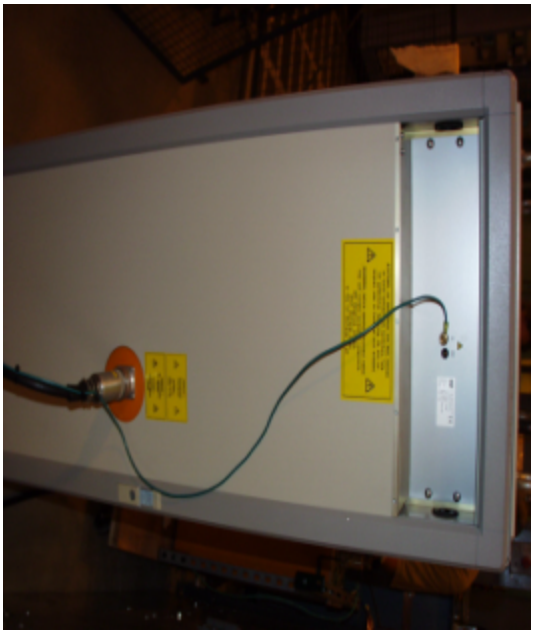

Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

Figure 14

Figure 15

Figure 16

Figure 17

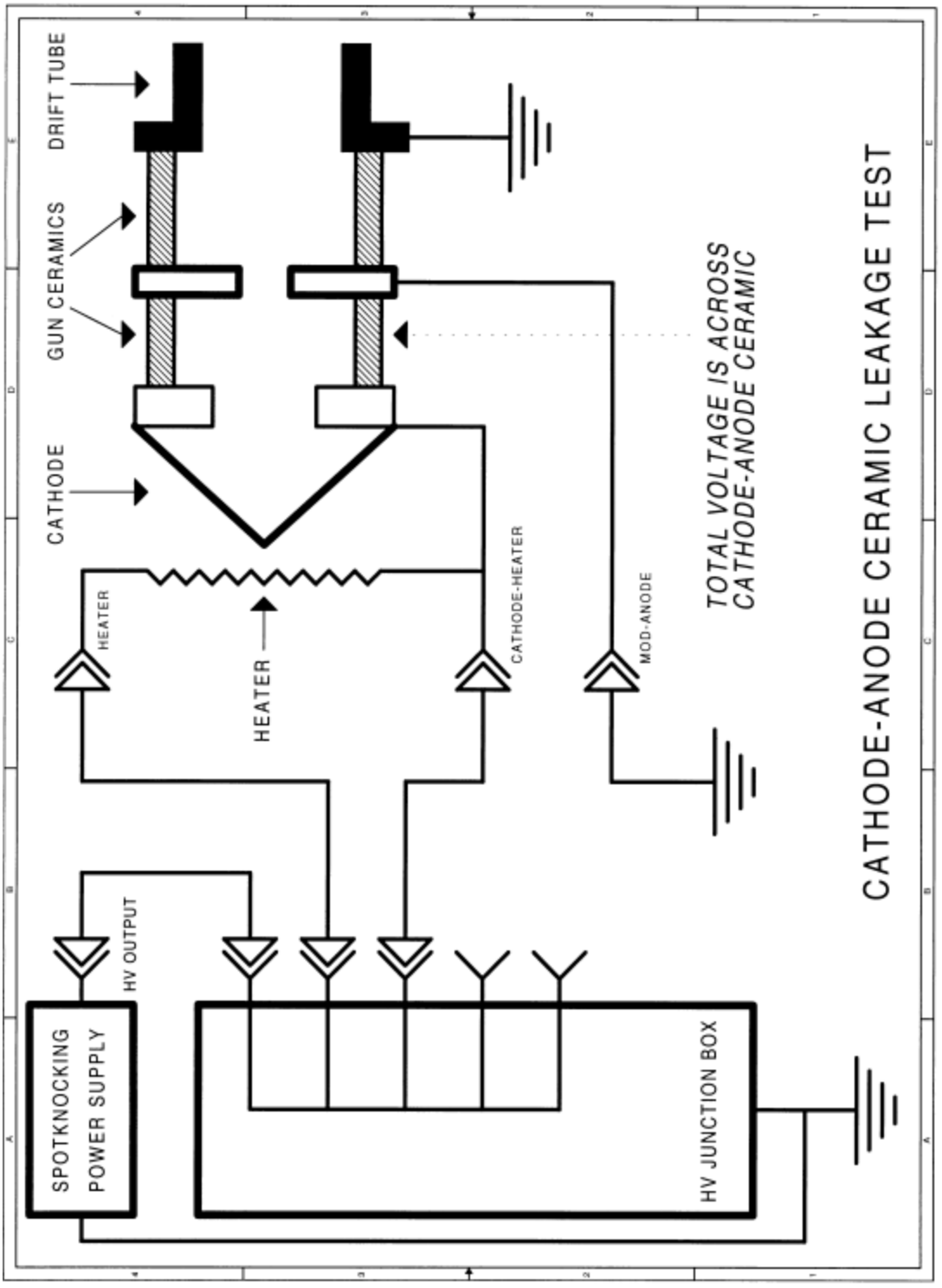
CATHODE-ANODE CERAMIC LEAKAGE TEST
DRIFT TUBE
GUN CERAMICS
CATHODE
HEATER
HEATER
CATHODE-HEATER
MOD-ANODE
TOTAL VOLTAGE IS ACROSS
CATHODE-ANODE CERAMIC
HV OUTPUT
SPOTKNOCKING
POWER SUPPLY
HV JUNCTION BOX

Figure 18