

# ARGONNE NATIONAL LABORATORY

## HIGH ENERGY PHYSICS DIVISION

# AWA

## ARGONNE WAKEFIELD ACCELERATOR

### RF SYSTEM OPERATING SYSTEM

Approved:

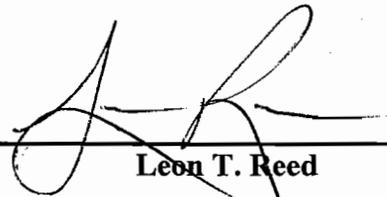
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Date: 3/19/07

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### RF SYSTEM OPERATING PROCEDURES

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## **INTRODUCTION**

This document is intended for use by a certified operator as a guide to safe, orderly and efficient operation of the accelerator. The system is designed to operate in three different modes: RF only, laser only and beam. To operate in the "RF only" mode, follow the modulator turn on procedure. To operate in "laser only" mode, follow the laser turn on procedure. To operate in the "beam" mode, follow the modulator and the laser turn on procedures independently and then the beam turn on procedure. **If any malfunctions occur, which make it impossible to satisfactorily complete any of the procedures, such malfunctions must be corrected before continuing.** Due to the complexity of the equipment and the multitude of malfunctions which may occur, no attempt is made to specify repair procedures. All repairs must be made in compliance with applicable safety standards. Think safety, work safely, injuries can last a lifetime and death is quite permanent.

**RF SYSTEM OPERATING PROCEDURES**

**TO START UP ACCELERATOR, PROCEED AS FOLLOWS:**

Please follow the steps in order. If a problem is encountered at any step, correct problem before continuing to next step. While moving from area to area, when performing the startup, make a visual check of the shielding to determine that all shielding is in place.

1. In Control Room, check Klystron Vac Ion Pump for proper operation. Voltage should be 5.4 KV to 5.6 KV and Current should be  $\sim 0$  uA.
2. Start up computer. Set RF gate width to 8130 nSec. and Laser coarse delay to 3455, then iconize this control panel. Set all focus system power supply controls to top of slide (minimum current settings).
3. Deleted step, space reserved for future use.
4. Outside Tunnel along east wall of tunnel, slowly open SF-6 cylinder valves. Do not adjust regulators at this time. High Pressure cylinder should indicate between 13 and 14 PSI and the Low-Pressure cylinder should indicate between 2 and 3 PSI.
5. Near top of Tunnel stairs, check vacuum gauges. (IG-2, IG-3 & IG-7). Readings should be:  
IG-2 lower  $10^{-8}$  range,  
IG-3 mid  $10^{-7}$  range or better if valve at exit end of linac tank 2 is open,  
IG-3 lower  $10^{-8}$  range if valve at exit end of linac tank 2 is closed,  
IG-7 lower  $10^{-7}$  range or better. (This gauge is off when window is installed at end of ten way.)  
Note: The two values for IG-3 are as much an indication of exit valve status as anything else.
6. Set Large Chiller to "Manual" if not in "Auto Start" mode. The flow meter at the in-line heat exchanger should show flow. (Set point should be  $89.0^{\circ}$ .)
7. Turn on Small Chiller.
8. Check that the heater for the circulator is "ON". Switch is on heater control panel in the left-hand relay rack (as viewed from laser room roof).
9. Turn on focus system power supplies.

10. Energize fiber-optic interlock system. Red switch at lower left corner of interlock status indicator panel. Press interlock reset button (green button near center at bottom of panel). Most status lights should light while switch is depressed and 3 or 4 remain on when switch is released. This shows that the system is working.
11. Get keys from Key Box and unlock Modulator Control Power disconnect switch. (Disconnect closest to outside wall).
12. Energize control power disconnect. Oil pump on Klystron tank should start.
13. Deleted step, space reserved for future use.
14. At Modulator Pump stand, start cooling water pump. Output pressure should be between 50 and 55 PSI.
15. In Control Room, reset fiber optic interlock relays. Reset switch (green) at bottom of status indicator panel. Most of the light should come on and stay on when switch is released.
16. At computer turn on Klystron heater (Klystron Heater Enable) on RF control window. If computer control was off, click enable button twice, if controls were on and screen locked click button once. Click set exact at bottom of heater voltage slide. Using set exact window that this opens, type in a setting of 3900 and click OK to ramp heater up to proper voltage. Observe klystron meters above fiber-optic interlock indicator panel to determine that the heater is actually being powered. If voltage does not start to run up in one minute, click abort at bottom of heater voltage slide control, reset voltage slide to zero and click enable button again. Restart runup. (Note: Kly Heater is interlocked with Kly Ion Pump under voltage and over current. If these are not picked up the as indicated by lamps on interlock panel the heater will not come on. Time for voltage to run all the way up is about 5 minutes. Periodically check Klystron ion pump current meter for rise in indicated current. If current exceeds about 10 uA, stop running up heater power until current returns to near zero. When fully run up, Klystron Heater Voltage should be 27 volts (adjust the setting up or down from 3900, if needed).
17. Periodically check at top of tunnel that main wave-guide pressure does not exceed ~14 PSI (Horizontal gauge near east railing) and low-pressure portion does not exceed ~2.5 PSI (gauge mounted on wave-guide feeding linac tank 1). Adjust regulators at gas cylinders if necessary. Also check that circulator is coming up to temperature and chillers are regulating properly. Total time for system to time out and reach operating temperatures is about 1 hour. (Minimum Circulator temperature at startup should be 108.5°F as indicated on digital thermometer at

Circulator or 48°C as indicated on panel meter on console. These values do not agree but this value is what the console meter indicates when the circulator is at proper temperature.)

18. When ready to start running, turn on Klystron solenoid power supply. Check current using DVM on supply front panel. (Proper reading is 68.7 +/- 0.1).
19. Take tunnel key and proceed to tunnel. Open beam line valves at vacuum map in Tunnel.
20. Turn on blower near Door #1.
21. At this time, the visual check that all shielding is in place must be completed. Do not secure tunnel unless all shielding is properly positioned. Close Door #1 and make Survey securing Door #2 for operation..
22. Return to Modulator, unlock and energize High Voltage disconnect.
23. In control room, depress interlock-reset switch. All indicator panel light in use should be on except "READY" and "CONTACTOR".
24. At computer, run "VVT" and "CHARGE DECK" control slides up and down a couple of times, ending with both set to zero, to assure CAMAC has reset to zero.
25. Insert key in RF lockout switch and turn on. "READY" indicator light should come on.
26. Depress "HIGH VOLTAGE ON" switch. "CONTACTOR" light should come on and high voltage meter should read upscale slightly (No more than 1 KV).
27. At computer, check that Laser trigger control is in the "Laser off" condition.
28. Set "CONTROL KNOBS" to "RF CONTROL".
29. Using knob, raise "VVT" control to ~5.0 and note that panel meter reads about 5 KV.
30. Set triggers to low rep. rate (1 or 2 Hz) and observe that scope traces indicate klystron voltage and current and are not breaking up due to klystron arcing. If arcing is indicated, go to single shot immediately and attempt to determine cause before proceeding. Raise "VVT" control to ~11.0 (~11 KV on panel meter).

31. If, during the following steps, arcing is indicated by the scope traces in either the klystron or high power RF, reduce power to eliminate the arcing or go to single pulse.
32. At computer, use "CHARGE DECK" knob to set PFN charging current scope trace to between 8 and 10 ms duration. This should give ~150 A. of klystron current.
33. Increase trigger rate to 30 Hz.
34. Use "CHARGE DECK" knob to adjust charging current scope trace to 10-ms duration. The current level indicated at turn off should be between 1/2 and 1 ms above baseline. Indicated klystron current (scope trace) should at or slightly above 150 Amps.
35. Using low level RF amplitude on control, slowly increase klystron drive until klystron saturation is reached. If a rise in pressure is observed on the accelerator ion gauge. (TV monitor above RF drive control), increase drive at a rate which does not cause the pressure to rise above  $10 \times 10^{-7}$  Torr, until klystron saturation is reached. Increase drive about 10% above this level to assure that the klystron operates in saturation without being overdriven.
36. Set the solenoid currents ("Bucking," "Gun" and "Linac") to proper levels for operation (around 2000 counts).
37. Using "VVT" control, increase Modulator high voltage to normal operating voltage. This level should be on the order of 19 KV. This should result in an indicated klystron current of 275 to 285 Amps and a gun cavity forward power of about 220 mV on the scope trace. Do not exceed a klystron current of 285 Amps. (Maximum rating of the klystron is 285 Amps).
38. Null out dark current on beam meter.
39. When ready for beam, set trigger control to the desired operating pulse rate (normally 5 Hz) and turn Laser control to "Laser On" condition.
40. Adjust Laser fine delay for maximum beam.

**TO INTERRUPT ACCELERATOR OPERATION, PROCEED AS FOLLOWS:**

1. Set trigger generator to single shot.
2. Turn off HV.
3. If access to Tunnel to make adjustments is desired, go to step 7.
4. If operator is leaving area and Tunnel access is not desired, place HV lockout key in key box.
5. Turn off Klystron Solenoid power supply.
6. De-energize HV disconnect and lock it out.
7. Remove HV key.
8. Take HV key with Tunnel access key attached and proceed to Tunnel door.
9. Remove a Safety Switch key from key interlock box and retain it on your person while in the Tunnel. **Do not** forget to replace key when leaving the area.
10. Unlock and open Tunnel door and proceed to make necessary adjustments.

**TO RESUME ACCELERATOR OPERATION, PROCEED AS FOLLOWS:**

1. If interruption was as in steps 1 through 6, turn on Klystron Solenoid power supply.
2. Check that Tunnel is still secured for operation (warning lights are still operating).
3. Obtain HV disconnect lockout key from key box, unlock and re-energize HV disconnect and replace key in key box.
4. Take HV lockout key from key box and return to console.
5. Depress interlock-reset switch (all indicator panel light in use should be on except "READY" and "CONTACTOR").
6. Insert key in RF lockout switch and turn on. "READY" indicator light should come on.

7. Depress "HIGH VOLTAGE ON" switch. "CONTACTOR" light should come on and high voltage meter should read the same voltage as before shutdown.
8. Set trigger control for desired pulse rate. RF signals on scope should be same as before shutdown.
9. Turn on Laser and proceed with operation.
10. If interruption was for Tunnel access, "Survey" Tunnel. lock Tunnel access door and return safety switch key to interlock key box.
11. Return to control room with HV lockout key (Tunnel access key attached).
12. Insert key in RF lockout switch and turn on. "READY" indicator light should come on.
13. Depress "HIGH VOLTAGE ON" switch. "CONTACTOR" light should come on and high voltage meter should read the same voltage as before shutdown.
14. Set trigger control for desired pulse rate. RF signals on scope should be same as before shutdown.
15. Turn on Laser and proceed with operation.

**TO SHUT DOWN ACCELERATOR, PROCEED AS FOLLOWS:**

1. Set trigger generator to single shot.
2. Turn of HV key switch and remove key.
3. Set Klystron heater voltage slide control to zero.
4. When panel meter indicates klystron heater voltage has reached zero, toggle heater enable control to off. (Timer light on interlock indicator panel should go off).
5. Set focus system power supply controls (beam line controls) for minimum current.
6. At modulator high voltage cabinet, de-energize and lockout high voltage disconnect.

7. Turn off klystron solenoid Power supply.
8. Close SF<sub>6</sub> cylinder valves. Do not move regulator controls or close regulator output valves.
9. Turn off chillers. If operation is planned for the next working day, set big Chiller for auto start.
10. Turn off focus system power supplies.
11. Obtain key and enter tunnel. Close GV-3 and any other beam line valves downstream of it.
12. Open Door #1 and turn off blower.
13. In control room, if modulator high voltage power supply has bled below ~10 KV, turn off fiber optic interlock power.
14. At modulator high voltage power supply cabinet, de-energize and lockout control power disconnect.
15. Return Tunnel and lockout keys to control room.

HAVE A GOOD DAY, OR AT LEAST WHAT IS LEFT OF IT.

### LASER TURN-ON PROCEDURE:

- Outside of Laser Room
  1. Check water pressure
  2. Check laser gas cabinet exhaust fan
  3. Check that tunnel laser shutter is closed
  4. Turn water on and check regulator pressure
- Inside of Laser Room
  1. Check laser beam path and remove all possible reflective materials.
  2. Check all the laser dyes in the pump

- Laser System Tune Up (General)

1. Set the Nd:YAG laser in operation mode
  - a. Turn electrical power on
  - b. Turn the interlock switch on
  - c. Turn Nd:YAG laser on and wait 30 minutes for warm-up
  - d. Maximize the output power
  - e. Check UV output of THG, Should be  $> 1.2$  W
2. Set Coherent 702 Dye Laser in operation mode
  - a. Turn dye jets on
  - b. Turn laser to lasing mode
  - c. Maximize power
    - (1) 60 mW for 2 jets mode
    - (2) 150 mW for 1 jet mode
3. Set the XeCl and KrF excimer lasers in operation mode
  - a. Turn power breakers for both lasers on
  - b. Turn interlock switch on
  - c. Check gas pressure in lasers and output power
  - d. Change laser gas if necessary
  - e. Maximize output power of FL2003 dye amplifier and UV output of THG
  - f. Maximize output power of final KrF amplifier

**THE LASER SYSTEM IS NOW IN OPERATION.**