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OPERATION OF THE HAZARDS CONTROL CALIBRATION FACILITY
NEUTRON GENERATOR

Jack H. Elliott

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OPERATION OF THE HAZARDS CONTROL CALIBRATION FACILITY NEUTRON GENERATOR

ABSTRACT

The operating procedure for the LLL Hazards Control Calibration and Standards Facility neutron generator is described. The generator is a Texas Nuclear Model 9400, and is located in the Low-Scatter Room. A general description of the generator is included.

INTRODUCTION

A Texas Nuclear^{*} Model 9400 neutron generator is located in a quadrant of the Low-Scatter Room (Cell A), and can produce 14.6-MeV neutrons through the reaction $T(d,n)^4\text{He}$ and 2.8-MeV neutrons through the $D(d,n)^3\text{He}$ reaction (see Fig. 1). Operation of the neutron generator depends upon production, extraction and acceleration of deuterium ions. After acceleration, the ions are allowed to strike a suitable target material to produce neutrons. These ions are generally accelerated to 150 kV. The generator is designed to produce 10^{11} neutrons/s at 14 MeV and 3×10^8 neutrons/s at 2.8 MeV. The ions are produced in a radio-frequency-type ion source which gives approximately 90% singly-ionized deuterons, resulting in high neutron production. A typical beam current that can be maintained for a long period is on the order of 250 to 300 μA for each of the sources.

A functional description of the generator is given in Appendix A.

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Fig. 1. (a). View of neutron target portion protruding above the floor.

Fig. 1. (b). Neutron generator suspended from Al grating floor.

OPERATING PROCEDURE

- Check the deuterium gas pressure (see Fig. 2). Increase the pressure to approximately 22 psi. If the pressure in the line was negative or you suspect that it has become contaminated, evacuate the gas line and repressurize with the following steps:
 - Open the regulator valve full clockwise.
 - Connect the vacuum pump to the pump-out connection on the section of tubing above floor level (see Fig. 3). Turn on the pump and open the pump-out valve.
 - Evacuate the line for approximately 5 min.
 - Close the pump valve. Close the regulator valve full counter-clockwise.
 - Open the main valve slightly.
 - Pressurize the line to 22 psi.
 - Close the main valve.
 - Cap off the pump-out connection.
- Open the main water return line located on the wall at the southeast corner of cell A.
- Open the main water supply line on the wall (1/4 of full open is enough).
- Read the meter on the control console showing generator vacuum pressure. The reading should be less than 5 mA, and must be less than 150 mA before any operation is attempted.
- Look to confirm that the isolation valve between the ion-pump and the target assembly is open (control box on top of Console, Fig. 4). If it is closed and the pressure is less than 2 μ at the target (as indicated on meter shown in Fig. 3), open the valve. If the pressure is greater than 2 μ , consider pumping out the target chamber as described below in the target change procedures.
- Turn on the keyed power switch (Fig. 5). Increase the D₂ gas control to read between 0.6 and 0.8 mA on the meter.
- Once the pressure rises, control the pressure in the region of 20 mA (meter reading) by increasing or lowering the D₂ control. Allow the gas to bleed into the vacuum for 2 min at the above pressure rate. Switch the beam on (up position). Turn on the solenoid switch (up position).

Fig. 2. Water and gas supply lines.

Fig. 3. Closeup of target chamber and vacuum gage.

Fig. 4. Control console.

Fig. 5. Closeup of controls.

- Walk into the low-scatter room and check the plasma color. It should be a redish pink glow. If a blue glow is present or the plasma is flickering, adjust the D_2 control for more gas.
- Make up the interlocks. The water must be flowing. All personnel interlocks must be made up; that is, the run-safe switch is truned to run, the door to cell A must be closed, and door key No. 1 must be turned on in the interlock control panel. In addition, the neutron generator panel key must be on.
- If the tritium target is in, call the Health and Safety Monitor to post warnings before continuing.
- Turn the high voltage (HV) control to zero and press the HV ON button (Fig. 5). Raise the voltage slowly to 150 kV.
- Beam extraction and focus controls: Extract the ions by raising both the focus and the extraction control values, keeping the focus value slightly ahead of the extraction control. When the desired beam current is approached, maximize the beam by finding the position for maximum beam for the focus. If the current is off the desired value, either lower or raise the extraction value. Readjust the focus again and alternate until the desired current is reached under the condition that the focus is also maximized. In some cases, where low beam currents are required, better control is obtained by defocusing the beam slightly and operating the focus control on the high side of the beam macimum position.

TEMPORARY SHUTDOWN

- Run the extraction control to zero.
- Run the focus control to zero.
- Turn the HV control to zero voltage and wait 20 sec.
- Press the HV OFF button.
- Cell A may now be entered.

Complete Shutdown

Continue the first four steps of the Temporary Shutdown procedure and then

- Turn the solenoid switch to OFF.
- Turn the beam switch OFF.

- Run the D_2 control to zero.
- Turn the generator key switch to OFF and remove the key.
- Shut the water supply off.
- Leave the water return valve open except when making a target change.

SPECIAL OPERATIONS

If power is to be removed from the generator, first remove the air hose to the solenoid controlling the target gate valve (Fig. 3). This allows the valve to remain open and avoids the possibility of leaking air into the vacuum system during valve operation.

TARGET CHANGE

- Close the isolation valve to the target. Control is shown in Fig. 4.
- Close both cooling water valves located on the wall by the well ladder.
- Remove water lines to the target at the water manifold in the lower level (Fig. 2).
- Drain water from system.
- Remove the target water cap (Fig. 3).
- Mop up water on the target and the cap.
- Open target pump-out valve and let target assembly up to atmospheric pressure with dry nitrogen (Fig. 6).
- Remove the target, dry it, and place it in a sealed container.
Dispose tissue used in active waste can.
- Dry the target assembly well.
- Install the new target, being careful not to scratch its surface.
- Center the target over the O-ring.
- Pump a little with a mechanical pump to secure the target. The mechanical pump is contained in the pump package shown in Fig. 7.
- Reinstall the water cap.
- Reconnect water lines at lower level.
- Begin pumping with a mechanical pump for a few minutes, then valve it off.

Fig. 6. Target chamber prepared for target change.

Fig. 7. Target chamber pump package.

- Immediately open the second cryopump until 50 μ pressure (Fig. 7 meter) is reached.
- Close it and open the No. 1 cryopump.
- Open the water return and supply. If the vacuum pressure (meter in Fig. 3) increases, shut the valves off and look for water leaks in the vacuum system.
- Continue pumping until the pressure in the target chamber is less than 5 μ .
- Close the target pump-out valve and immediately open the target isolation valve.
- Cap off the pump-out valve.
- Continue pumping with the ion pump until the pressure drops to give a gauge reading of 5 mA or less.
- The system is ready for operation.

APPENDIX A

FUNCTION DESCRIPTION OF THE TEXAS NUCLEAR MODEL 9400 NEUTRON GENERATOR

The neutron generator can be divided into six basic parts: (1) the high-voltage source, (2) the ion source, (3) accelerating system, (4) target system, (5) vacuum system and (6) remote control console.

The source of high voltage is an oil-insulated power supply, consisting of a 75-kV transformer with half-wave rectification and voltage doubling. The output voltage is continuously variable from 0 to 150 kV with a rated current output of 5 mA.

The ion source is an improved radio-frequency source of the type developed at Oak Ridge National Laboratories. This source is capable of producing ion beam currents in excess of 1 mA. This ion current is composed of approximately 90% atomic ions and 10% molecular ions. Operation of the ion source is remotely controlled from the console. When the accelerating potential is applied, the ion source components are at the high-voltage potential (150 kV max) with respect to earth ground. Input voltage (115 V a.c.) for operation of the ion source components is obtained by means of a 150-kV isolation transformer.

The target system consists of a solid tritium-titanium target with suitable beam collimating, a microammeter located on the control console, and an electron suppressor.

The vacuum system consists of a vac-ion type pump, a section with pump-out valve and thermocouple gauge, a mechanical "roughing" pump, and a gate valve. A molecular sieve-type foreline trap is also provided for the purpose of eliminating back-streaming oil vapors from the mechanical pump. The system will reach a static vacuum of approximately 5×10^{-7} mm Hg. The pump current is proportional to the pressure in the ion pump so that the power supply for the ion pump acts as its own vacuum gauge. A mechanical pump is used to obtain a pressure of less than 10μ prior to starting the ion pump.

All controls and metering circuits are located in the control console. The extraction voltage, focus (gap lens) voltage, palladium leak voltage, on-off switch for r-f oscillator, solenoid voltage switch and accelerating voltage are remotely controlled from the console. Meters on the console measure the output voltage and current of the 150-kV power supply, the beam current on the target, and vacuum readings from the ion pump and the thermocouple gauge.

The controls for the ion source are electromechanically coupled to the ion source terminal.

For further description read the manufacturer's manual.

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