NEW RESISTOR VOLTAGE GRADING SYSTEM AT THE OAK RIDGE
NATIONAL LABORATORY 25URC TANDEM ACCELERATOR; INSTALLATION
AND FIRST EXPERIENCE*

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1. Introduction

On June 27, 1994, installation work was completed on a new resistor-based voltage grading system for the Holifield facility tandem accelerator. This new system replaces the original point-plane corona-discharge system which had inherent disadvantages. Perhaps the worst disadvantages of corona-discharge systems are poor gap-to-gap voltage homogeneity and very low grading currents. It is believed that the resistor-based system will reduce or eliminate these disadvantages as well as some others.

2. Design and Initial Tests

The design and initial tests of the resistor assemblies have been described and will only be briefly reviewed. The principal features of the design are its simplicity and the fact that it relies on the tube or column post spark gap for spark protection. Figure 1 shows the tube resistor design. One unit of the accelerator (1/27th) has been equipped with resistors for approximately three years and eight months. No damage or significant change in resistance value was observed during this period. It should be noted that these resistors were not operated at their expected full installation voltage (corona-discharge currents being only a few microamperes), but that they did log almost 6000 charging chain hours and sustained 90 full-column sparks.

The Welwyn model number 394475 resistor is manufactured to a National Electrostatics Corporation specification which is considered to be proprietary. The resistors have the following non-proprietary characteristics:


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3. **Installation**

The 25URC tandem accelerator has a total of 2562 voltage grading gaps of which 474 are column post gaps which require two resistors. Therefore, a grand total of 3036 resistors were assembled and installed in the accelerator. Figure 2 shows a typical tube section with resistors while Fig. 3 shows the column post configuration. Each column assembly is offset by approximately 90° so that adjacent spark gap assemblies are as far apart as possible. Resistor installation was done in three steps. First, the assembly was attached to the gap and adjusted for tightness and overall spacing on the tube or column post. The second step involved a careful physical inspection of each installation by another individual. Problems were noted and resolved before the last step, which was measurement of the resistance of each gap. The measurement was done using a Keithley model 487 picoammeter/source with the source voltage set at 500 volts.

4. **Conditioning**

The first operation with the resistors in place was a conditioning exercise. This exercise was necessary for two reasons, one of which was that the low-energy acceleration tube had been exposed to dry nitrogen for approximately two weeks to accommodate alignment work for the new radioactive ion beam project. More importantly, the exercise was conducted to assure stable operation with the resistors for the development work currently being performed with beams from the accelerator. A terminal potential of 20.7 MV was easily achieved with a total of 50 hours of conditioning time.

5. **Low-Voltage Transmission Tests**

One of the motivations for resistor installation was operation of the accelerator at terminal potentials down to 1 MV without shorting units or changing the SF$_6$ pressure. The new astrophysics initiative at HRIBF requires low-energy beams for some of the most interesting experiments and provided some motivation for this mode of operation. In the first test of low-voltage operation, the overall transmission efficiency for a $^{16}$O beam was measured in the beam energy range 50.3 to 2.3 MeV. The essential result of these measurements is that the accelerator can be operated at a terminal potential of 1 MV to produce 2.3-MeV beams. While it is clear that ultra-low terminal potential operation will require further development work on the terminal potential regulation system, it was encouraging to note that the overall beam
transmission efficiency at 2.3 MeV was observed to be only a factor of two lower than the observed beam transmission efficiency at 50.3 MeV, for which the terminal potential was 12.5 MV. It is probable that this transmission could be increased with proper shorting to enhance the optics. In any case, it has been shown that very low energy beams can be provided from the 25URC after installation of resistors.

6. Discussion

Operation with resistors has been smooth and has fulfilled our expectations in all cases to date. Some of the expected gains, such as increased injected current capability and higher terminal voltage, have not been tested at this time. Injected current has been dictated by ion source performance and development run requirements with the maximum current being 3.4 µA since the resistor installation. It is believed that injected current could be increased easily to 4 µA and probably higher. The high voltage tests will be undertaken in a few months when the machine is available for conditioning.

7. Acknowledgments

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8. References


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Figure 1. Section view of a typical tube resistor with protective end caps.
Figure 2. Simplified views of the installation of resistor elements on an NEC high-gradient 17-cm-long accelerator tube section.
Figure 3. Section view of a typical column resistor and its mounting scheme on the column post.