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IMPROVED VOLTAGE PERFORMANCE OF THE OAK RIDGE 25URC TANDEM ACCELERATOR*

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INTRODUCTION

The Oak Ridge 25URC tandem electrostatic accelerator^{1,2} is one of two accelerators operated by the Holifield Heavy Ion Research Facility³ (HHIRF) at the Oak Ridge National Laboratory. Placed into routine service in 1982, the accelerator has provided a wide range of heavy ion beams for research in nuclear and atomic physics. These beams have been provided both directly and after further acceleration by the Oak Ridge Isochronous Cyclotron (ORIC).⁴

Shown schematically in Fig. 1, the tandem accelerator is a model 25URC Pelletron accelerator manufactured by the National Electrostatics Corporation (NEC). Although designed to operate at terminal potentials up to 25 MV, its operation had been limited to 23.5 MV for demonstrations and 22.0 MV for scheduled experiments. These limits were partially programmatic in origin, but were also related to limitations which appear to have been associated with the acceleration tube – most basically, a tendency to spark at higher terminal potentials.

While voltage performance of the accelerator has been adequate for the experimental program to date, it seemed clear that improvement in voltage

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performance could be of direct benefit to the experimental program in the future. Therefore, we began, in June 1986, a program of modifications and tests which was designed to improve voltage performance of the accelerator. In this paper, we discuss the final phase of this program and initial tests of the accelerator following completion of this final phase.

COMPRESSED GEOMETRY ACCELERATION TUBES

One of the principal changes in the present program was replacement of the original acceleration tubes with tubes of a compressed geometry design. In this design, which utilizes a modified NEC high-gradient 17-cm-long tube section, the 3-cm-thick heatable aperture assembly provided as part of the original installation is replaced with an aperture assembly of essentially zero length. A schematic view of the original installation in the 25URC column is shown in Fig. 2, which may be compared with the same view of the installation of compressed geometry tubes shown in Fig. 3. With this change, seven tube sections can be installed in the space previously occupied by six, thus increasing the effective insulator length per unit column length by a factor of $7/6 = 1.17$. Tests on a compressed geometry configuration, similar to that described in this report, were first reported by Assman et al.⁵ A subsequent test, using a column structure more closely resembling the 25URC column, was reported by Raatz et al.⁶

The installation and tests described in this report represent the last of three phases of the tube replacement program for the 25URC accelerator. In the first phase, two tube units,⁺ 26 and 27, were replaced with compressed geometry tubes in June 1986 and tested in the interval July 1986 to October 1986.⁷ In the second phase, units 19–25 were replaced with compressed geometry tubes in November 1986 and tested in the interval November 1986 to March 1987.⁸ In the present phase, the remaining 18 units were replaced. Detailed discussions of the results of the first and second phases, as well as details of the compressed geometry acceleration tube design and installation, have been provided in Refs. 7 and 8. In the final installation, the 30° vee-shaped aperture discussed in Ref. 8 was used in all but units 19–22. In these units, conventional, straight, 1-mm-thick apertures were used. A section view of a

⁺ The configuration of the 25URC accelerator is based on 27 61-cm-long live modules or "units" separated by two major and three minor dead sections. Proceeding from bottom to top, the units are grouped in the following way: 1–4, 5–9, 10–13, 14–18, 19–22, 23–27.

compressed geometry tube section equipped with vee-shaped apertures is shown in Fig. 4.

VOLTAGE GRADING

In order to compensate for the increased number of insulating gaps in the acceleration tube, it was necessary to decrease the point-to-plane spacing of the tube corona points from 4.4 mm to 3.3 mm. This was accomplished by fabrication and installation of new corona point assemblies with points of increased length. Corona point assemblies for both the acceleration tubes and column were mounted using holders of a new design.⁹ As expected, these holders have proved more reliable than the original holders.

As noted by Weisser,¹⁰ mechanical adjustment of corona points is not adequate to achieve good voltage homogeneity. To alleviate this problem, the corona points used for the present tests were adjusted electrically in air using a current regulated power supply to measure the voltage required to produce a constant test current, typically 20 μA , for each gap. Using this technique, it was possible to adjust the corona point spacings so that the gap voltages varied by less than $\pm 10\%$.

COLUMN PREPARATION AND ACCELERATION TUBE INSTALLATION

Previous measurements,^{2,8} on the longitudinal voltage gradient and radial voltage capabilities of the column strongly suggest that the column is not a limiting factor in voltage performance. However, to help insure that this would not be the case in the future, we carefully inspected and cleaned the column prior to installation of the compressed geometry acceleration tubes. The first step in this process was removal of the acceleration tubes, the Pelletron chains, and column corona points. Each column post insulating gap was then cleaned by blowing with compressed, dry N_2 and visually inspected. As a result of this visual inspection, approximately 15 of 8,262 gaps were subsequently cleaned with ethanol and Q-tips. The resistance and spark gap breakdown voltage of each column plane (16 column post gaps + 1 corona point support post gap) was then measured. No significant problems were noted as a result of these inspections and tests. We specifically found no indications of the column post structural problems noted by Brinkley et al.¹¹ As the final step in this work, the column

was carefully cleaned and the tightness of column rings and transverse interconnecting elements was checked.

As noted in Ref. 8, the upper one-third of the accelerator, units 19–27, had previously been equipped with compressed geometry acceleration tubes. The tubes in units 19–25 had been in service since November 1986 and in the present phase were only removed, stored on site, and replaced. The tubes in units 26+27 were installed in June 1987 as part of an auxiliary (unsuccessful) test of surface finish technique. These tubes were replaced along with those from units 1–18.

As indicated in Ref. 8, the compressed geometry tubes were, with noted exceptions, to be assembled from previously used tube sections. Thus the tube sections removed from units 1–18 and 26+27 were returned to the NEC plant where they were visually inspected, modified, and fitted with new insert electrodes. In contrast to the tube sections previously used to assemble compressed geometry tubes, these tube sections were not sandblasted. After installation, the tubes were baked at an average temperature of about 100°C for approximately 24 hours while pumping with the major dead section and terminal sputter ion pumps. In the previous installations of compressed geometry tubes,^{7,8} the tubes were not baked.

CONDITIONING AND TESTING

Conditioning of the accelerator following completion of the installation of the compressed geometry tubes in November 1987 was performed in three major phases. The first phase, which had as its primary goal return of the accelerator to service for the experimental program, ended in early January 1988. Several observations during this first period are of interest. First, the tubes in units 19–25 conditioned more easily and rapidly than those in units 1–18 and 26+27. Thus, the removal, disassembly, storage, and installation of the used tubes did not cause them to completely revert to the behavior of tubes with new insert electrodes and apertures. The tubes in units 19–25 also exhibited "classic" pulsed x-ray conditioning while the newly assembled tubes in units 1–18 and 26+27 exhibited virtually no pulsed x-ray conditioning. When compared on the basis of achieved stable voltage as a function of time or number of sparks, the conditioning behavior of the tubes in units 1–18 and 26+27 was comparable to the initial conditioning of the tubes previously installed in units 19–27.⁸ It thus appears that there are no significant differences in conditioning behavior which

may be associated with baking at $\sim 100^{\circ}\text{C}$ for 24 hours or with sandblasting of the ceramic.

Following a period of operation for the experimental program at terminal potentials up to 20 MV, the accelerator was conditioned for a second period of 18 days in April/May 1988. At the end of this period, the tubes in units 19–25 had been (easily) conditioned to a stable gradient of 1.0 MV/unit, while the tubes in units 1–18 and 26+27 had been conditioned to an average stable gradient of 0.95 MV/unit. At the end of the period, stable operation of the accelerator, with beam, was demonstrated at 24.0 MV (for one hour, without sparks or tics).

Following a second period of operation for the experimental program at terminal potentials up to 23.4 MV, the accelerator was conditioned for a third period of 18 days in August/September 1988. At the end of this period, pairs of units and individual units had been conditioned to an average stable gradient of approximately 1.04 MV/unit, and stable operation of the accelerator with beam, was demonstrated at 25.5 MV (for one hour without sparks or tics). A few days after completion of these tests, the accelerator was operated for use in the experimental program at a terminal potential of 25.0 MV.

DISCUSSION

From an operational viewpoint, installation of compressed geometry acceleration tubes and the associated changes in the column and tube voltage grading systems has been a success. The maximum demonstrated stable voltage with beam has increased from 23.5 MV to 25.5 MV and the maximum terminal potential used in an experiment has increased from 22.0 MV to 25.0 MV. In a more general sense, the improved terminal potential performance of the accelerator has had an immediate positive effect on our experimental program, allowing us to provide beams of higher energy and intensity.

We wish to emphasize that we believe that the results reported here are preliminary in the sense that the ultimate terminal potential capability of the accelerator has not been reached. Specifically, our experience with conventional tubes has been that voltage performance continues to improve over a period of several years with use and conditioning. It also appears that adequate tube grading currents may not be

provided with the present corona points. We hope to rectify this problem in the near future. Finally, we do not believe that we have a complete understanding of how tank gas pressure should be adjusted for operation above 22 MV. We expect our understanding of this question to improve as we routinely operate the accelerator at higher potentials.

In summary, installation of compressed geometry acceleration tubes and associated changes in the corona voltage grading system has resulted in significant improvement in voltage performance of the 25URC accelerator. Further improvements, resulting from detailed changes in the corona voltage grading system and increased operating experience, are expected in the future.

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REFERENCES

1. J. K. Bair, J. A. Biggerstaff, C. M. Jones, J. D. Larson, J. W. McConnell, W. T. Milner, and N. F. Ziegler, IEEE Trans. Nucl. Sci. NS-22, No. 3 (1975) 1655.
2. C. M. Jones, Proc. Third Int. Conf. on Electrostatic Accelerator Technology, Oak Ridge, Tennessee (April 1981) p. 23.
3. C. M. Jones, G. D. Alton, J. B. Ball, J. A. Biggerstaff, D. T. Dowling, K. A. Erb, D. L. Haynes, D. E. Hoglund, E. D. Hudson, R. C. Juras, S. N. Lane, C. A. Ludemann, J. A. Martin, M. J. Meigs, S. W. Mosko, D. K. Olsen, and N. F. Ziegler, Nucl. Instr. and Meth. A268 (1988) 308.
4. J. A. Martin, D. T. Dowling, D. L. Haynes, E. D. Hudson, C. M. Jones, R. C. Juras, S. N. Lane, C. A. Ludemann, M. J. Meigs, W. T. Milner, S. W. Mosko, D. K. Olsen, and N. F. Ziegler, Proc. Eleventh Int. Conf. on Cyclotrons and Their Applications, Tokyo, Japan (October 1986) p. 38.
5. W. Assmann, G. Korschinek, and H. Münzer, Nucl. Instr. and Meth. 220 (1984) 86.
6. J. E. Raatz, R. D. Rathmell, P. H. Stelson, and N. F. Ziegler, Nucl. Instr. and Meth. A224 (1986) 104.
7. C. M. Jones, K. A. Erb, D. L. Haynes, J. T. Mitchell, N. F. Ziegler, J. E. Raatz, and R. D. Rathmell, Proc. 1986 Symp. Northeastern Accelerator Personnel, Notre Dame, Indiana (November 1986) p. 65.

8. C. M. Jones, K. A. Erb, D. L. Haynes, J. T. Mitchell, N. F. Ziegler, J. E. Raatz, and R. D. Rathmell, Nucl. Instr. and Meth. A268 (1988) 361.
9. N. F. Ziegler, G. D. Mills, M. J. Meigs, R. L. McPherson, R. C. Juras, C. M. Jones, D. L. Haynes, G. D. Alton, Proc. 1987 Symp. Northeastern Accelerator Personnel, Tallahassee, Florida (September 1987) p. 5.
10. D. C. Weisser, Nucl. Instr. and Meth. A268 (1988) 419.
11. T. A. Brinkley, G. P. Clarkson, M. D. Malev, T. R. Ophel, R. B. Turkentine, and D. C. Weisser, Nucl. Instr. and Meth. A244 (1986) 89.

HHIRF TANDEM ACCELERATOR

Fig. 1. A simplified schematic drawing of the Holifield facility tandem accelerator.

ACCELERATING TUBE OLD GEOMETRY

Fig. 2. A schematic view of the installation of original geometry tubes in the 25URC accelerator column.

ACCELERATING TUBE COMPRESSED GEOMETRY

Fig. 3. A schematic view of the installation of compressed geometry tubes in the 25URC accelerator column. In this installation, one column support post gap is shorted in order to match the number of column and tube gaps for each tube section.

Fig. 4. Section view of compressed geometry tube section with vee apertures.

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