TESTING AND OPERATION OF THE WR340 WAVEGUIDE WINDOW IN THE APS LINAC*

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Abstract

The Advanced Photon Source (APS) linac high-power switching system makes extensive use of SF6 pressurized, WR340-size waveguide, incorporating waveguide switches. A tunable, extra low return loss waveguide window has been developed to support interfacing the pressurized waveguide with the original waveguide, which is under vacuum. The tunable approach is able to consistently achieve a return loss of at least 40 dB. Test and alignment methods, performance, and initial operating experience are described.

1 INTRODUCTION

The rf power for the APS linear accelerator [1] is provided by five 2856-MHz klystrons (L1 through L5), each of which feeds one linac sector. The original klystrons are Thales model TH2128, rated at 35 MW peak. Recently, the process of upgrading new and rebuilt klystrons to model TH2128D, rated at 45 MW peak, has started. This will become the new standard for the APS linac as the remaining lower power klystrons are retired or rebuilt with the power upgrade. L1 feeds rf power to one of two thermionic rf guns via the exhaust of one accelerating structure. L2, L4, and L5 are conventional sectors, each using a SLED cavity assembly [2] to feed four accelerating structures. L3 supplies rf power to the photocathode gun located at the beginning of the linac. For normal storage ring injection operation, L1, L2, L4, and L5 are operated, and for R&D operation, all five units are operated.

The change from positron to electron operation in the APS storage ring changed the linac configuration by eliminating the L3 accelerating structure. A sixth klystron-modulator subsystem had already been installed in the linac gallery. Therefore both the third and sixth klystron-modulator subsystems are not ordinarily used for storage ring injection.

2 SYSTEM REQUIREMENTS

A pair of waveguide distribution and switching systems has been designed for the APS linac [3]. Each switching system allows a klystron-modulator combination, either the third or sixth subsystem, to serve as a hot spare for either of two other klystrons and can be used for test and R&D activities while on standby. Each of the four klystrons being spared has a function that is essential for APS storage ring injection. This configuration constitutes a change from the original design of the system [4] that would have allowed the sixth subsystem to serve as a hot spare for any of the others.

The first system, which covers the guns and lower energy sectors, is now installed. It is functional and has made substantial commissioning progress, but is not yet considered fully operational. In this low-energy system the L3 klystron serves as a hot spare for the L1 and L2 klystrons and powers either the photocathode rf gun, to support LEUTL operation, or the gun test room. In the second, or high-energy system, the L6 klystron serves as a hot spare for the L4 and L5 klystrons and powers the test stand for switches and other high-power waveguide components. Implementation of the high-energy system has been on hold pending the possible installation of additional accelerating structures. It is now expected to be scheduled in the near future.

The distribution and switching system makes extensive use of WR340 waveguide and waveguide switches, which operate in an environment that is pressurized with SF6. In order to most effectively interface this waveguide with the original vacuum environment waveguide while avoiding SF6 environment stress levels that could compromise system availability, an extra low return loss WR340 waveguide window has been developed and is now in service as part of the waveguide switching system. In order to permit use of multiple windows and still achieve a good return loss at the klystron outputs, a 40-dB return loss design goal was established for the window.

3 DESIGN CONSIDERATIONS

The window development uses an already existing, SLAC, WR284 window design as a starting point [5]. In order to assure reaching the desired extra low return loss, two additional tuning features have been incorporated in the design. Plungers are adjusted to optimize return loss while the window is restrained by a special fixture after brazing but before a final TIG weld that secures each plunger to a conflat flange. Each plunger contains a small circumferential groove very close to the face, into which a beryllium copper spring is inserted. The spring maintains

*Work supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38
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good electrical contact around the plunger face and avoids the undesirable situation in which high power can be delivered to a narrow slot. Four external tuning adjustments, which can be set after brazing, welding, and assembly, are also available for tuning. These tuning methods are used in addition to possible use of the SLAC method of selecting the thickness of the copper vacuum gaskets used during final assembly of the window. Figure 1 is a sectional view showing the adjustable plungers with the small circumferential groove and beryllium copper spring as well as the four external tuning adjustments.

4 LOW-POWER TESTING

Low-power testing for return loss is initially performed after brazing but before the TIG weld that secures each plunger to a conflat flange. The window remains assembled in a specially designed brazing-adjustment fixture and is tested on a network analyzer. The brazing-adjustment fixture evolved as necessary in order to provide settings that were sufficiently precise and repeatable. Figure 2 shows one half of the brazing-adjustment fixture assembled to a window. Adjustment of the fixture allows movement of the plungers, which have not yet been welded in place. Sliding the plungers changes the volume of the cavity surrounding the ceramic, thereby initially tuning the window for minimum return loss at the operating frequency. However, experience has shown that there is typically a small change in effective volume during welding. Therefore, the initial tuning is optimized about 20 MHz higher than the operating frequency. Up to now, welding has been accomplished on one side, followed by a repeat measurement, before proceeding with the second side. However, with increasing experience, we expect to be able to skip the extra steps. After all brazing and welding is complete, the window is assembled using copper vacuum gaskets one thickness increment greater than was used during the initial test. The window is again measured on the network analyzer. The four external tuning adjustments can then be used to re-optimize return loss at the actual operating frequency.

5 HIGH-POWER TESTING

High-power testing, up to a 45-MW peak maximum, at a 4.5-µs pulse width, and a repetition rate of 30 pps, is performed after tuning is complete. The test is performed with high vacuum on one side of the window and SF_6, at a pressure of 30 psig, on the other.

6 CURRENT STATUS AND PLANS

Four of the windows are presently in service. A fifth could not be completed after a ceramic metalizing failure. Four more windows are in process to replace existing work-around configurations using WR284 windows. Two additional windows are in process to support testing and for use as spares. Installation of the high-energy system would require six additional windows.

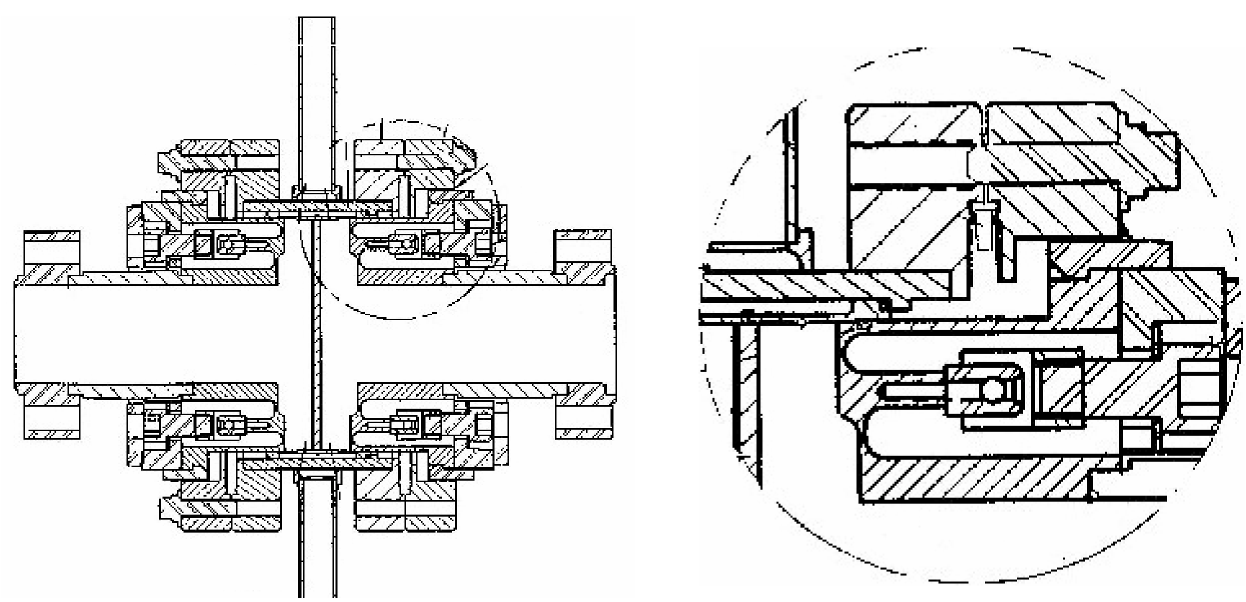

Figure 1: Window sectional view with detail.

Table 1 gives S11 and S21 measurements for the completed windows. Figure 3 is an example of an installation, showing two windows installed on either side of a waveguide switch.

Table 1: Window Measurements

S/N	S11	S21
340-1M	50.7 dB	0.01 dB
340-2	50.7 dB	0.01 dB
340-5	55 dB	0.01 dB
340-22	47 dB	0.01 dB

High-power testing, up to the 45-MW peak maximum available at APS, has been uneventful. No testing at SLAC has been scheduled so far, but it would certainly prove valuable in gatherng more information about peak power handling capability. Operation of the waveguide switching system incorporating the windows has been limited by procedural safeguards and increases in timing complexity, without regard to the windows or any other high-power component.

7 ACKNOWLEDGMENTS

The authors gratefully acknowledge D. Meyer for operation and support of the high-power tests; W. Michalek, M. Martens, and V. Svirtun for cleaning, alloying and assembly; J. Hoyt for supervision and general assistance; G. Gorski for precision machining; and C. Eyberger for editorial assistance.

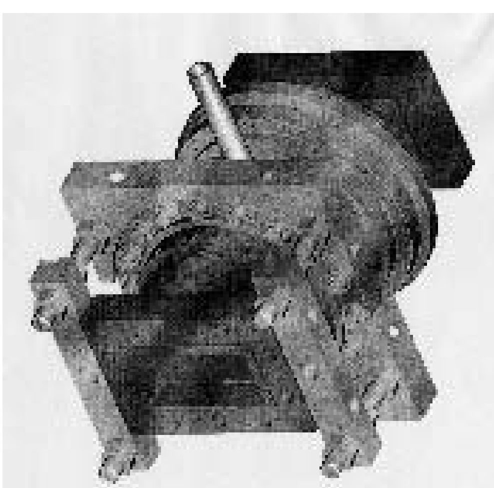

Figure 2: Half of brazing-adjustment fixture assembled to window.

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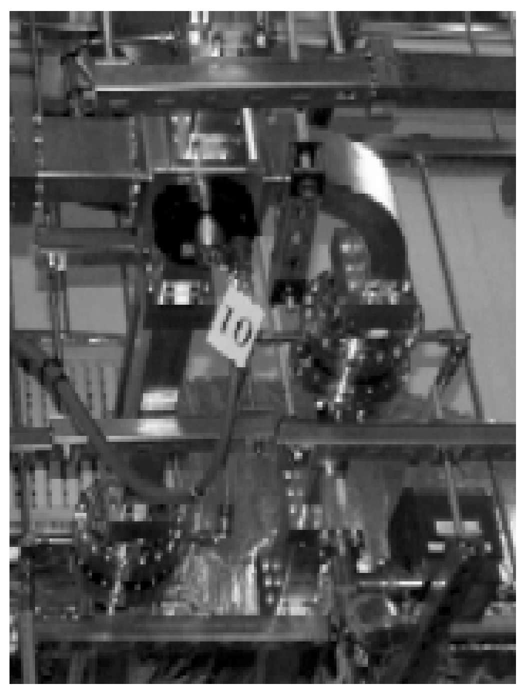

Figure 3: Typical installation.