

# RF TEST RESULTS OF CHOKE FLANGE FOR HIGH POWER WAVEGUIDE VALVES

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## Abstract

We need a waveguide valve with a peak rf power handling capability of 80 MW or more to reduce the replacement time of klystron tubes in the PLS linac. So we designed a wave-guide valve and made two prototypes. However, they have some problems caused by rf power leak from the waveguide to the vacuum enclosure. This leak power caused increase of vacuum pressure and arcing in the vacuum chamber at the power level of 60 MW. A new choke flange has been designed with a MAFIA code to solve problems caused by the rf power leak. A model choke flange has been fabricated, and tested with a network analyzer and 600 W solid state amplifier. It was observed that the rf leak at the choke flange can be reduced more than 20 dB in comparison with no choke case.

## 1 INTRODUCTION

The PLS 2 GeV linac is serving as a full energy injector to the storage ring for the third generation synchrotron source. Up to the present, the total accumulated high voltage run-time of the K&M system has already reached average (25,000) hours per module. We expect more than (30,000) hours of the tube lifetime because the operational power level is approximately 65-85 % of the rated power level. Three klystrons have been replaced with tubes so far. We have experienced that about a week period is required to recover the original operating condition of the vacuum pressure and the rf power of accelerating structures after the tube replacement. At present, the vacuum pressure of the accelerating section ranges of between  $5.5 \times 10^{-8}$  and  $3.5 \times 10^{-9}$  Torr, and we observe very little breakdowns and multipactoring.

We have a gate valve between accelerating modules for vacuum isolation. When the klystron or any rf component is replaced, the gate valves isolates the troubled linac module, and the electron beam can not pass through. Since the user service schedule for the light source runs continuously for a few months period, it is absolutely necessary to minimize the repair time.

In order to solve this problem, other linac machines are using waveguide valves or rf windows to separate the vacuum between klystron and accelerating structures. The Viton-seal type best waveguide valves were developed at SLAC, and they have been used quite a period of time for ~65 MW peak power with 3.5  $\mu$ sec

pulse length. A new waveguide valve for 80 MW at 4.3  $\mu$ sec pulse length has been designed by PLS with the collaboration work with IHEP, China. Two prototypes of the waveguide valve have been fabricated at PAL. We will describe the high power rf test results of prototypes and describe a new choke flange design for a waveguide valve to improve the problems.

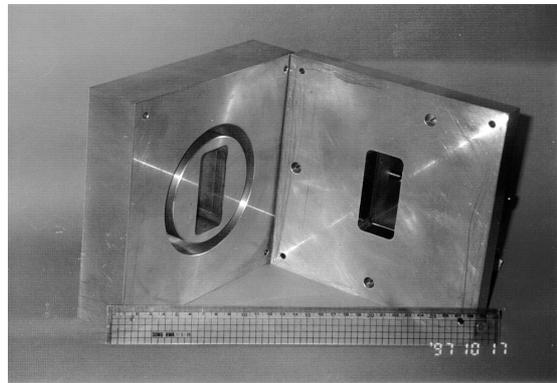


Figure 1: A model choke flange for rf cold test

## 2 PROTOTYPES

The prototype of the wave-guide valve consists of a U-type wave-guide part for transmitting rf power, a sealing plate for isolating the vacuum between a klystron and accelerating structures, actuators for driving the U-type waveguide part and the vacuum sealing part, and a chamber. The chamber of the first prototype is made of SUS304 and the second one is made of aluminum. The cold test results show that these ones has good performance at low power. But we cannot confirm with these results that they will work well at high power such as 80 MW power or more.

High power tests were executed for several cases. For the first prototype, the vacuum pressure suddenly went up at the rf power of 60 MW with 3.5  $\mu$ s pulse width and 30 Hz repetition rate [1]. There were some arcing traces inside the chamber. The high power tests of the second one were conducted at the resonant ring in the PLS. We used three different combinations of seal materials for rf and vacuum. Also the second prototype shows similar symptoms as the first one at the rf power of 150 MW with 0.8  $\mu$ s pulse width.

After intense reviews, we found a few problems in the prototype valve. The first problem is the increase of the

vacuum pressure in the chamber caused by the rf leak. The second one is the arcing problems occurred at the inside of the chamber and the rf contact point of waveguide. The last one is the different vacuum pressure between the inside and the outside of waveguide in the chamber during high power operation. All problems are coming from the rf leak which is from the incomplete contact of the rf seal.

### 3 DESIGN OF CHOKE CAVITY

Problems of the rf breakdown and the vacuum pressure increase are originated from the rf leak at rf seal flanges. Therefore, we have to consider how to minimize the leak power to the chamber and keep the same vacuum pressure of the chamber as the pressure of the waveguide. There are two ways to minimize the leak power to the chamber. One way is to absorb the rf leak power. And the other way is to minimize the leak power.

Before finding a solution for these problems, it is necessary to decide the design criteria for a wave-guide valve. First of all, we have to know the maximum tolerable rf power in the chamber which means the rf isolation between the waveguide and the chamber. Unfortunately, we do not know the exact value because it depends on the shape, the vacuum seal material, chamber material. A SLAC waveguide valve developed recently shows that the maximum tolerable rf leak power was set at 2 W peak in the O-ring chamber [2]. We refer this value when we design a new valve. The ratio of power transmitted the waveguide valve to the leak power in the chamber should be greater than 80 dB for operation at 100 MW to get this value. We think that it is impossible to get 80 dB rf isolation with only this rf seal type. A new type of rf seal with a choke cavity as shown in Fig. 2 is designed with the MAFIA simulation code to achieve 80 dB isolation and to solve the problem of the different vacuum pressure between the chamber and the waveguide simultaneously. The choke cavity has a function to reflect the leak rf power.

There are four parameters in a choke cavity: position, depth, width of the choke and the gap between flanges to be determined. The gap distance and choke width are decided as 1 mm and 10 mm, respectively. The gap distance has affect on the rf reflection ratio (VSWR) in the waveguide. In case of  $d=1$  mm, calculated VSWR is less than 1.1, even if all leak power is reflected back [3]. This is the reason why we choose  $d=1$  mm. But the choke width was decided arbitrarily. And the other parameters are decided by the computer simulation. The simulation results are shown in Fig. 2 and Fig. 3. We can determine the choke dimensions with this results. The choke position for an operating frequency can be determined from Fig. 3 and the choke depth is decided from the

relationship between these two parameters as shown in Fig. 2.

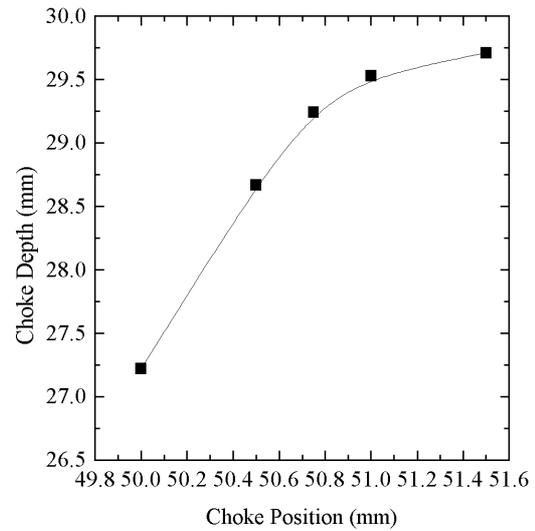


Figure 2: Relation between choke position and choke depth ( $d=1$ mm)

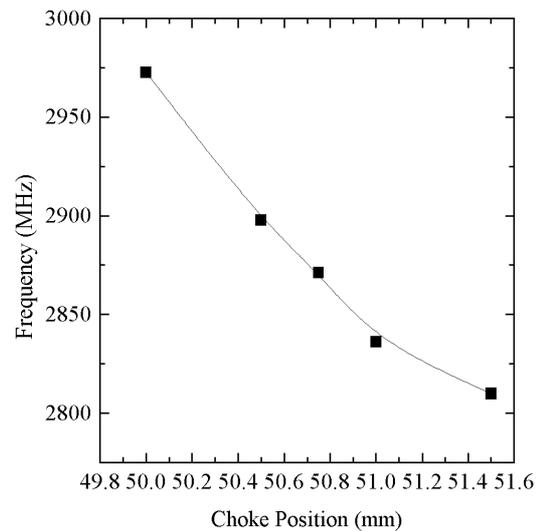


Figure 3: Relation between choke position and resonant frequency

### 4 RESULTS

For the computer simulation we obtain a choke which has dimension of choke depth=29.29 mm, choke position=50.84 mm, choke width=10 mm, and gap=1 mm for the operating frequency of 2856 MHz. With above dimensions a model choke flange has been fabricated (see Fig.1), and tested. There are three measurement points located at outside of choke and numbered as show in Fig. 4.

We measure the rf leak power at three points using a network analyzer (HP8510C) and a solid state amplifier in two case, namely, with choke and without choke in the flange. The results are shown in Fig. 5 and Fig. 6.

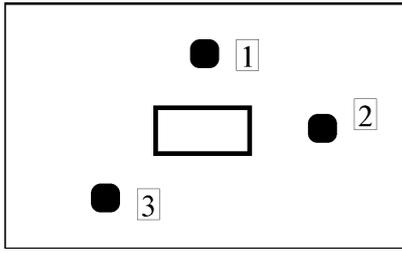


Figure 4: Port location and number for measurement at flange

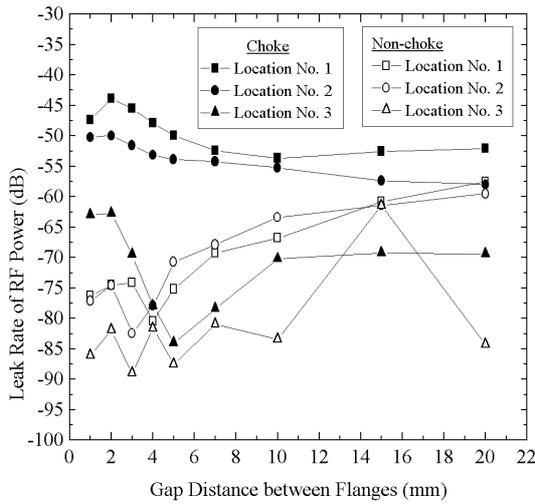


Figure 5: Leak rate of rf power through the gap between flanges by using a network analyzer

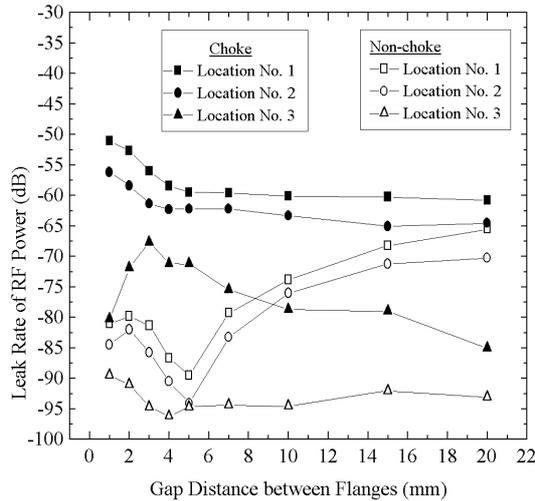


Figure 6: Leak rate of rf power through the gap between flanges by using a solid state amplifier of 600 W (pulse)

## 5 DISCUSSION AND CONCLUSIONS

We get similar results in two test cases that one is using a network analyzer and the other is using a solid state

amplifier of 600 W pulse. When we compare two cases of the plane flange and the choke flange we know that the leak power at the flange gap can be decreased at least 20 dB by using the choke flange. Using a choke flange is only one solution among many solutions. This choke type valve has advantages and disadvantages compared to the prototype. Advantages are that rf leak will certainly be smaller than the prototype, and different vacuum pressure problem will disappear.

Disadvantages are that the volume of valve will be bigger and the weight of it will be heavier. Another way to solve rf leak problem is using rf absorbing material. However, it also been problems need to be solved.

Based on the positive cold test result, we fabricated a prototype of a choke flange for high power test, and the picture is shown in Fig. 7. This will be tested in the S-band resonant ring in PAL. When we get expected results from the hot test we will adapt this choke flange for a new waveguide valve.

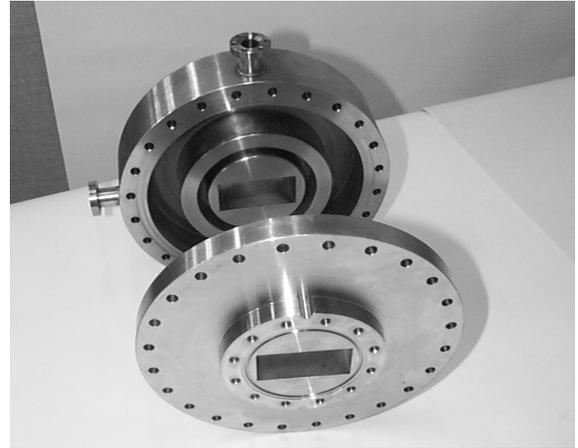


Figure 7: A prototype choke flange for hot test

## 6 ACKNOWLEDGMENTS

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## 7 REFERENCES

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