

# WAVEGUIDE CHANNEL FOR TNK LINEAR ACCELERATOR-INJECTOR

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80 MeV linear accelerator is a part of the industrial storage facility at the State Research Institute for Problems in Physics named after F.V. Lukin (Moscow, Zelenograd). 6-meter long accelerating DAW structure operates at 2.8 GHz and is powered by the Olivin klystron station. The power is transmitted through the long waveguide channel made of rectangular copper pipes with 90·45 mm cross section and 5 mm walls, with no circulator. The paper deals with the waveguide channel construction features, including indium gaskets to connect individual parts. The waveguide channel length correction procedure for the purpose of overvoltage decreasing during accelerating structure breakdowns is also described.

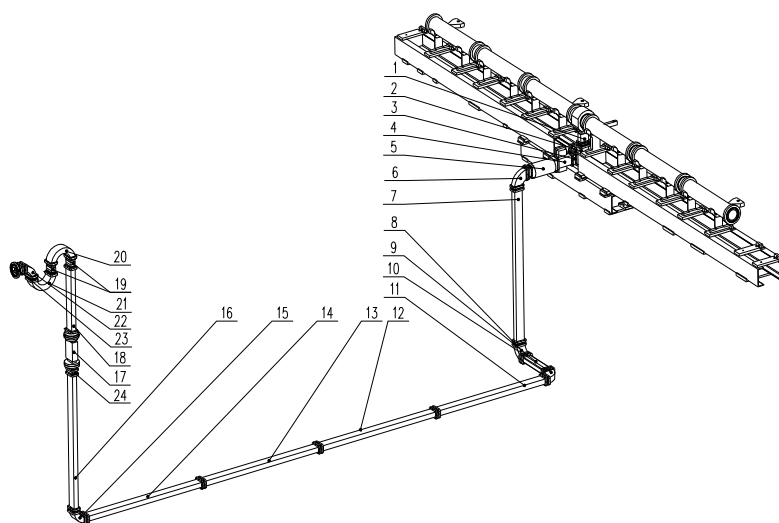
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## 1. INTRODUCTION

The waveguide channel connects the RF power source (KIU-53 klystron) with the accelerating structure. The 6-meter long disk-and-washer (DAW) accelerating structure operates at 2.8 GHz. The maximum power level transmitted through the waveguide is 18 MW at pulse duration up to 10  $\mu$ s with repetition rate up to 5 pps.

## 2. DESIGN

The waveguide channel is shown in Fig.1. Its length is about 15 m with cross-section of 45·90 mm<sup>2</sup>. It consists of a vacuum section connected to the linear accelerator and a gas section connected to the klystron. Separation of these sections is realized by a TWS-type waveguide window, which has been developed by S.Yu. Kazakov [1] and has been produced at INP subdivision in Protvino.



*Fig.1. Waveguide channel: 1–reducer; 2–turn; 3–manometer unit, 4–directional coupler; 5–waveguide window; 6–turn; 7–turn; 8–turn; 9–waveguide; 10–turn; 11–waveguide; 12–waveguide; 13–waveguide; 14–waveguide; 15–turn; 16–waveguide; 17–directional coupler; 18–waveguide; 19–spacer; 20–turn; 21–turn; 22–turn; 23–connector assembly; 24–gas unit*

The waveguide input of the accelerating structure has a conjunctive size for waveguide cross-section of 34·72 mm<sup>2</sup>. So, the reducer (1) with the connected turn (2) is used. The manometer unit (3) is used for vacuum measurements. The next is the directional coupler (4) used for incident and reflected wave voltage measurements in the waveguide. The waveguide window (5) ends the vacuum part of the waveguide. Its vacuum pumping is effected from the accelerating structure, connected to it.

The gas section of the waveguide channel contains the directional coupler (17), used for measurements when operating on the equivalent load, as well as the staggered phase shifter, formed by elements (19) and (20). The waveguide channel is connected with the klystron by connecting unit (23). Filling by dry nitrogen is carried out via the gas unit (24). Turns (6, 8, 15 and 22) and waveguides (7, 9, 10, 12, 13, 14, 16 and 18) provide the space configuration of the waveguide chan-

nel suitable for the location of the klystron, accelerating structure, and building structures.

Waveguide elements are mainly made of copper. Seamless copper pipes with inner rectangular cross-section  $45 \cdot 90 \text{ mm}^2$  and outer rectangular cross-section  $55 \cdot 100 \text{ mm}^2$  were used to produce waveguides (7, 9, 10, 12, 13, 14, 16 and 18).

Conjunction of waveguide channel separate parts was performed with indium seals, which provided both

conjunction tightness and electrical conduction. Variant of flange brazing to waveguides was declined because of waveguide pipe shrinkages during brazing.

Still, brazed flanges have been used in short elements such as turns, directional coupler, reducer, etc. Here, contact-sealing section design has been made similarly to the described below. An example of construction of the conjunction with throw on flange is shown in Fig. 2,3.

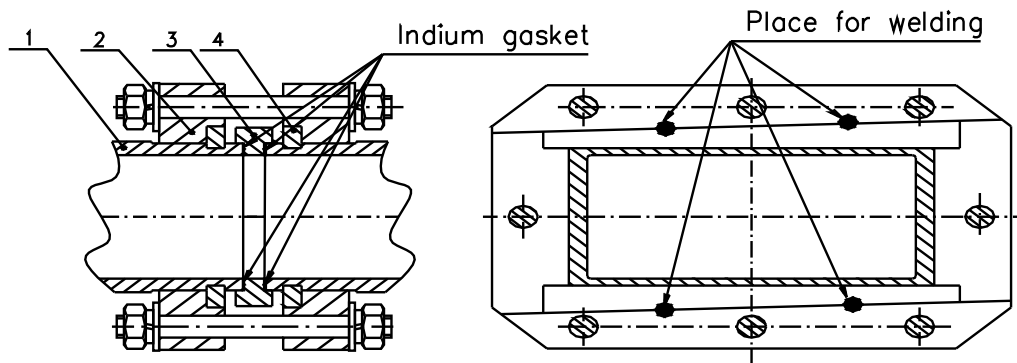


Fig.2.

1 – waveguide, 2 – flange, 3 – frame, 4 – spline

The waveguide end (1) is handled to the required dimensions, so that the flat surface accuracy at end-walls is not worse than 0.05 mm and surface finish is not worse than Ra 1.6. Two flutes are implemented along the wide sides. The junction assembling is carried out in the following sequence. At first, the flange 2 is installed on the waveguide end 1, then draw keys are installed into the flutes of the waveguide end 1 and flange descent 2. After that, brazing are carried out in four places (see figure) to prevent moving and rotating of these wedge splines. The second waveguide is handled in the same way. The frame 3 serves for mutual fixation of the waveguide ends. The  $\varnothing 0.7 \text{ mm}$  indium wire is fastened on contact surfaces of the frame and is flattened down to 0.1...0.2 mm thickness. The frame is provided by special slots of rectangular shape for wire holding, its contact surfaces have flatness not worse than 0.05 mm and surface finish not worse than Ra 1.6. Then the waveguide to be connected are placed on the adjustable bench (not shown). The frame is inserted between waveguide ends; the construction is constricted with studs. By doing so, the indium wire is finally squashed down to 0.03...0.05 mm thickness and pressurizes the junction providing good electrical conduction. Flanges and splines are made of common carbon steel, and the frame – of stainless steel 12X18H10T.

### 3. TUNING

The accelerating structure operates in the energy accumulating mode [2], so gently inclined fronts of the RF excitation pulse are allowable. This circumstance enables us to exclude sharp differences at pulse fronts and omit the circulator. Tuning of the waveguide channel

length consists in measurement of its eigenfrequencies near the operating frequency in order to detune them, and matching the waveguide length to be divisible by

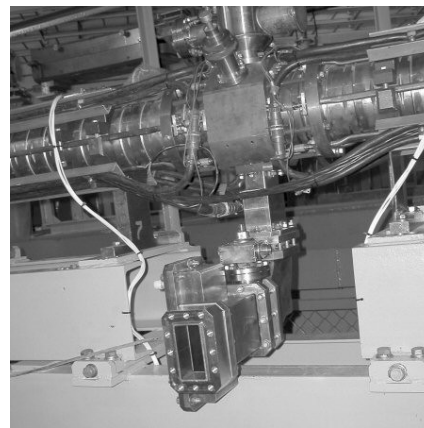


Fig.3. Waveguide fragment

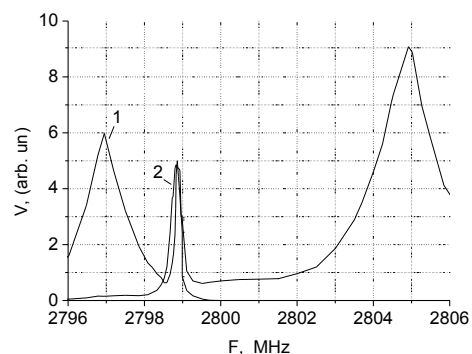


Fig.4. Resonant frequencies of the waveguide (1) and linear accelerator (2)

$(2n+1)\lambda_w/8$  to decrease overvoltages. It is realized by changing the electrical length with the set of waveguide spacers of different sizes (pos. 19 on Fig.1). The measurements were carried out at lowered anode voltage of KIU-53 klystron down to 100 kV, when the klystron output cavity was practically the RF current generator exciting the waveguide. Figure 4 shows the dependence of the incident and reflected wave voltage within a frequency range. The ceramic window disc is placed at a distance  $L=n\lambda_w/2$  from the accelerating structure input to decrease the overvoltage on the window at accelerating structure discharges.  $\lambda_w$  is the wavelength in the waveguide,  $n$  is the integer.

#### 4. CONCLUSION

The waveguide channel is easily assembled. Junctions between its elements have no irregularities, pro-

viding air-tightness and good electric contact. It proves correctness of choice of indium as a material for contact-sealing gaskets. During balancing and commissioning of the linear accelerator, there were no discharges in the waveguide at a power level up to 10 MW. Seal failures in the vacuum and gas section were not observed too.

#### REFERENCES

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#### ВОЛНОВОДНЫЙ ТРАКТ ЛИНЕЙНОГО УСКОРИТЕЛЯ - ИНЖЕКТОРА ТНК

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Технологический накопительный комплекс НИИФП им. Ф.В.Лукина, г. Зеленоград в своём составе имеет линейный ускоритель на энергию 80 МэВ. Ускоряющая структура ЛУ с шайбами и диафрагмами (DAW) длиной 6 м работает на частоте 2,8 ГГц. Источником ВЧ-мощности для неё служит клистронная станция «Оливин». Передача мощности осуществляется длинным волноводным трактом, выполненным из медных прямоугольных труб сечением 90×45 мм и толщиной стенок 5 мм, без циркулятора. Рассмотрены особенности конструктивного выполнения волноводного тракта, в котором используются индиевые уплотнения для соединения отдельных элементов. Также приведена процедура настройки длины волноводного тракта с целью уменьшения в нём перенапряжения при пробоях ускоряющей структуры.

#### ХВИЛЕВІДНИЙ ТРАКТ ЛІНІЙНОГО ПРИСКОРЮВАЧА - ІНЖЕКТОРА ТНК

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Технологічний накопичувальний комплекс НІДФП ім. Ф.В.Лукина, м. Зеленоград у своєму складі має лінійний прискорювач на енергію 80 МеВ. Прискорююча структура ЛП із шайбами і діафрагмами (DAW) довжиною 6 м працює на частоті 2,8 ГГц. Джерелом ВЧ-потужності для неї служить клістронна станція «Олівін». Передача потужності здійснюється довгим хвилевідним трактом, виконаним з мідних прямокутних труб перетином 90×45 мм і товщиною стінок 5 мм, без циркулятора. Розглянуті особливості конструктивного виконання хвилевідного тракту, у якому використовуються індійові ущільнення для з'єднання окремих елементів. Також приведена процедура налаштування довжини хвилевідного тракту з метою зменшення в ньому перенапруги при пробоях структури.