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OPEN DRIFT TUBES FOR A-1 TANK OF ISTRA-56 LINAC

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Abstract Open-to-vacuum drift tubes with rare-earth quadrupole lenses for A-1 tank of 56 MeV ISTRA-56 linac are described. Measurements of field spatial distribution in the lens aperture, estimates of lenses and drift tubes parameters at various stages manufacturing are discussed.

INTRODUCTION

The use of rare-earth magnet lenses in the drift tubes of Alvarez-type tanks allows to make the drift tubes much more compact and, hence, to increase the frequency of accelerating field and the linac efficiency. The mechanical designes of such drift tubes are rather different. In some cases the magnets are fixed in the lens by epoxy compounds, in others - mechanically.

In the case of epoxy containing lens it is preferable to make the drift tube body vacuum-tight. However, the presence of strong magnetic field in the welding area (especially in the aperture) makes the task of reliable vacuum-tight welding very complicated.

In the drift tubes where the lens magnets are fixed mechanically the vacuum-tightness is not necessary. Nevertheless there is a problem of reliable fixing of magnets which are rather brittle. Besides, as the interior of the drift tube is open to high vacuum, it is necessary to choose such materials for constructional elements that would not deteriorate vacuum quality.

The design of open-to-vacuum drift tube satisfying these requirements was developed at ITEP. The set of drift tubes for A-1 tank of ISTRA-56 linac was manufactured.[1,2]

RARE-EARTH MAGNET LENS DESIGN

The set comprises thirty three 50 mm long lenses (each consisting of two 25 mm long sections) and two 25 mm long semilenses.[3] Each section consists of two layers of rod magnets positioned in duralumin cylinders. There are 12 rods in the first layer and 18 - in the second. The lens magnetic aperture - 21.2 mm. Also, there is the third cylinder embracing the first two. Originally it was designed for the third layer of magnets in order to provide the rated value of gradient. But in the course of lenses manufacturing it became clear that two layers are quite enough and so the third cylinder is used only as a constructional element.

The 7.4 mm in diameter rod magnets are positioned in the specially-profiled holes (see Fig.1). The keyway on the side surface of the rod prevents it from turning in the hole after positioning.

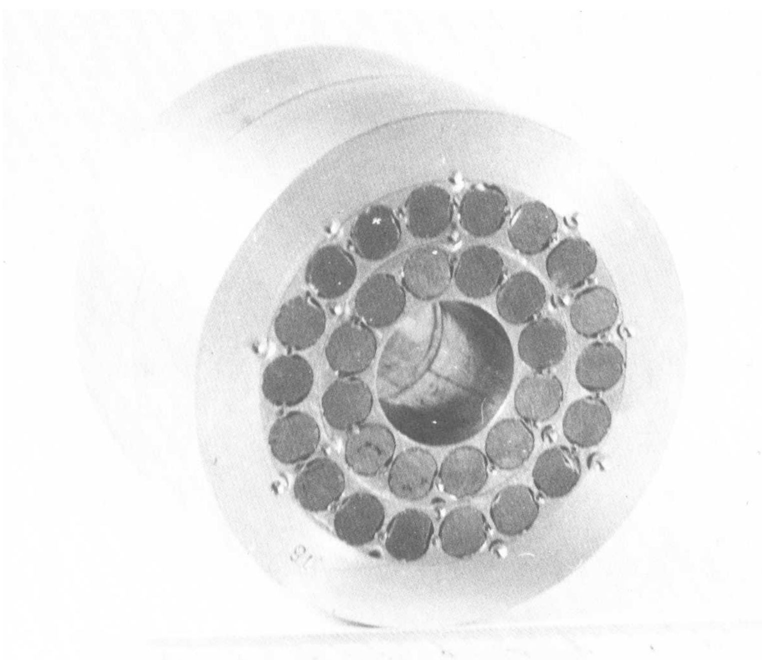

FIGURE 1 Rare-earth quadrupole lens for open drift tube.

DRIFT TUBE DESIGN

The drift tube body is fabricated from oxygen-free copper. The lens is fixed in the main part which has a cooling jacket (see Fig.2). After mounting of the side cups their electric and thermal contact with the main body is provided by welding. As there is no need in vacuum-tight welding the weld depth is rather small (0.3-0.5 mm).

The interior of the drift tube is pumped through a number of holes drilled in the main part body. The location of the holes is such that the residual gas flows are directed from the axis of the drift tube and do not cause local deterioration of vacuum in the aperture and the accelerating gaps. Vacuum tests showed that the drift tubes of such a design allow to provide the desired vacuum in the tank volume.

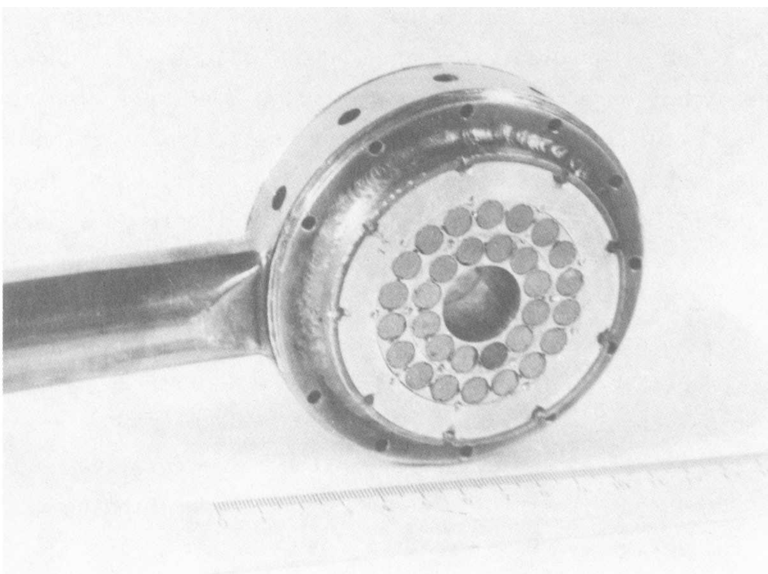

FIGURE 2 Open drift tube with rare-earth magnet lens (view on the interior).

LENSES AND DRIFT TUBES PARAMETERS CONTROL DURING MANUFACTURING

During manufacturing magnetic measurements were held at three stages.

At the first stage the needed number of rods was selected from the batch of 3500 magnets. The quality of each rod was estimated by the value of parameter Φ/l, where Φ - magnetic flux excited by the magnet in the measuring core, l - the length of the rod. The results obtained allowed to select the sets of rods for each layer, the spread of the parameter being not more than 0.5%.

At the second stage each layer passed measurements. Two parameters were taken into consideration: the value of gradient and the value of displacement of the magnetic axes from the geometric one. All data were computer prosessed. The special machine code allowed to select the pairs of layers. The main task was to obtain the maximum number of pairs satifying the tolerance for the displacement of the magnetic axis from the geometric one and at the same time providing the rated value of gradient. This procedure allowed to provide the displacement not more than 0.03 mm (rms value over all lenses). The rated value of gradient was obtained by relative rotation of the layers. The excess in summary value of gradient allowed to do this.

At the third stage the field space distribution of each lens mounted in the drift tube and also the field nonlinearity were measured. The measurements were carried out at the special precision stand. The main part of the stand is 3-D measuring computer-controlled table for precision positioning of Hall probe. For data prosessing a special set of machine codes was developed.

The magnetic field was measured in the representative points of seventeen cross-sections (the accuracy of probe positioning is 0.0025 mm for x and y axes and 0.04 mm for z).

At the end of each measurement the operator obtains the listing with the results of proximate analysis of the drift tube quality. The listing contains data on field nonlinearity and the displacement of the magnetic axis from the geometric one for each cross-section.

The integral value of the gradient complied with the tolerance of 1%. Harmonic contents in the middle of the drift tube was 0.5-0.7%, gradient nonlinearity - 1-1.5%. The rms deviation of the real magnetic axis from the linearized one was from Ø.Ø1 to Ø.Ø2 mm.

The geometric parameters (length) of the drift tubes were measured by conventional methods (micrometer). But for additional control several drift tubes were checked at the above-mentioned precision measuring table. In this case also the perpendicularity of side surface of the drift tube to its axis was measured. The results of the measurements showed that the tolerance for drift tube length of ±Ø.Ø2 mm was satisfied.

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