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TITLE: A 6.7 MEV CW RFQ LINAC

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A 6.7-MeV CW RFQ Linac *

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A 6.7-MeV 350 MHz, cw Radio Frequency Quadrupole proton linac has been designed and is being fabricated for the Accelerator Production of Tritium Project at Los Alamos. This eight-meter long structure consists of four resonantly-coupled segments and is being fabricated using hydrogen furnace brazing as a joining technology. Details of the design and status of fabrication are reported.

The linear accelerator for the Accelerator Production of Tritium Project (APT) [1] will include a 6.7-MeV Radio Frequency Quadrupole (RFQ) linac. The first phase of the project, the Low Energy Demonstration Accelerator (LEDA) [2], is to demonstrate performance of the RFQ plus a CCDTL [3] to 20 MeV. The technical specifications for the APT/LEDA RFQ are given on Table I.

TABLE I: APT/LEDA RFQ SPECIFICATIONS

PARAMETER	VALUE
Frequency	350.00 MHz
Particle	H^+
Input Energy	75 keV
Input Current	105 mA
Input Emittance, trans./norm.	0.020 π-cm-mrad rms
Output Energy	6.7-MeV
Output Current	100 mA
Output Emittance, trans./norm. longitudinal	0.022 π-cm-mrad rms 0.174 deg-MeV
Transmission	95%
Duty Factor	100 %
Peak Surface Field	1.8 Kilpatrick
Average Structure Power	1.2 MW
Average Beam Power	0.7 MW
Average Total Power	1.9 MW
RF Feeds	12 Waveguide Irises
Average Heat Flux	11 Watt/cm²
Maximum Local Heat Flux	65 Watt/cm²
Resonant Segments	4 @ 2.0 meters each
Brazed Sections	8 @ 1.0 meters each
Slug Tuners	128 total
Length	8.0 meters
Weight	5000 lb.
Inlet Coolant Temperature	50°F
Operating Temperature	85°F

The design and construction of an RFQ to deliver an average proton current of 100 mA at 6.7-MeV is a significant challenge for the beam dynamics and thermal management. The original concept of the APT/LEDA RFQ was developed in 1993 [4]. Since then a number of the physics parameters have changed to reflect revised requirements for matching to the LEBT and CCDTL as well as to take advantage of improvements in the transport codes [5]. Along with this, the fabrication concept has changed from the electroformed-joint design developed for the BEAR Project [6] to a furnace-brazed design [7].

Subsequent sections of this paper describe the cavity design, the engineering design, and the present status of the fabrication.

PHYSICS DESIGN

The physics design is discussed in detail elsewhere in these proceedings [5]. The parameters are plotted in Figure I.

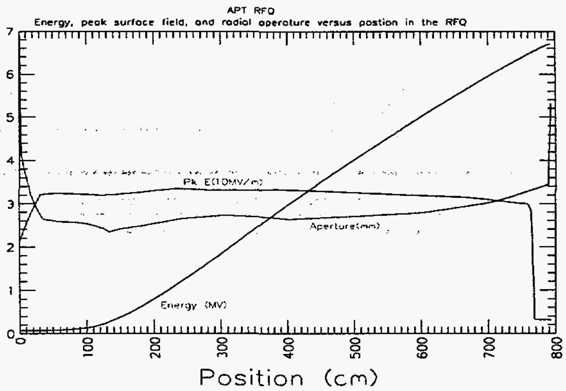

Figure I: Calculated Physics Parameters
(Peak Surface Fields are Divided by 10)

CAVITY DESIGN

The cavity cross-section is the "conventional" triangular shape with a significant longitudinal variation in the width of the vane skirt. The skirt dimensions are shown on Figure II. This profile minimizes the power deposited on the cavity walls.

The 8-meter-long structure is designed as four resonantly coupled 2-meter-long segments [8] to assure longitudinal stabilization. Stabilizer rods [9] on the inter-segment coupling plates and end walls provide azimuthal stabilization without the scalloping of the on-axis fields associated with vane-coupling rings [10] or pi-mode stabilizers [11].

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* Work Supported by the US Department of Energy

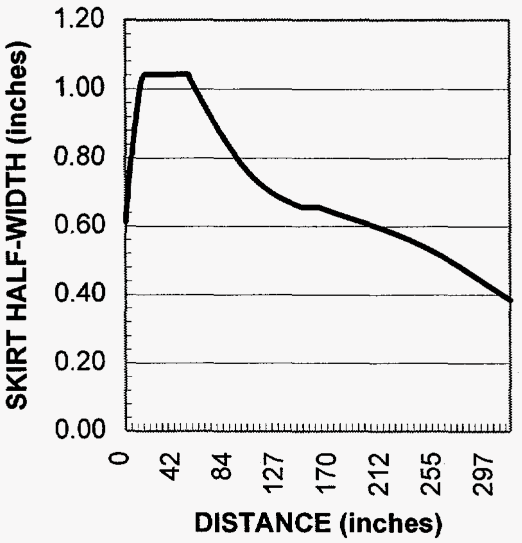

Figure II: Vane Skirt Width Variation

ENGINEERING DESIGN

The cavity is fabricated as eight one-meter-long sections each consisting of two major and two minor vanes. There are 24 longitudinal coolant passages in each of the sections to remove the 1.2 MW of average structure power. These are machined into the OFE-copper substrate and then plugs are brazed on. In order to provide coolant passages as near as possible to the vane tips, the vane tips are fabricated separately and brazed onto the vane bases. These are the only water-to-vacuum braze joints and they are a double joint of nearly one-inch width. This is shown on Figure III.

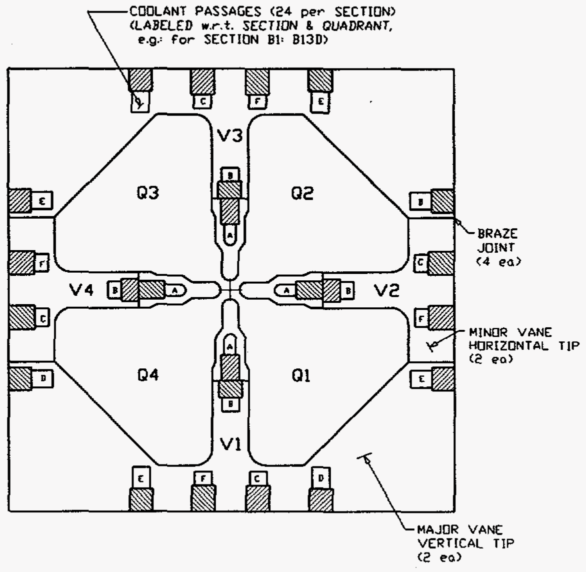

Figure III: RFQ Cross-Section

For resonance control, the tip coolant passages ("A" & "B") are operated with 50°F coolant while the temperature of the coolant in the outer ("C,", "D," "E," & "F") passages is modulated to maintain the cavity on resonance. The rf power in each of the four resonant segments is significantly different (A = 188, B = 318, C = 361, & D = 398 KW respectively) and the inlet temperature of the coolant is varied accordingly. The error signal for the resonance control system is derived from the reflected power. A compromise between longitudinal temperature variation in the sections and flow-erosion considerations led to a decision for a maximum bulk velocity of 15 ft/sec. The total flow through the cavity is 1,190 GPM.

The peak surface heat flux on the cavity walls is 13 W/cm^2 at the high-energy end. The peak temperature on the cavity wall surfaces is predicted to be 100°F. The peak surface heat flux in the undercut region at the high-energy end is predicted to be 65 W/cm^2 with the peak temperature in this region predicted to be 130°F.

The 50°F inlet coolant temperature requires a refrigeration system instead of the cooling tower more commonly used for linacs. The cooling tower would provide an inlet coolant temperature of about 105°F with correspondingly higher peak surface temperatures on the cavity walls and end undercut regions. The higher temperatures on these surfaces would have higher thermal loads due to increased surface electrical resistance. Additional rf power would also have been required with the higher coolant inlet temperature.

The beam loss will be approximately 5 mA of H$^+$ and will occur in the first section. The vacuum system will have eight 8-inch cryopumps which includes installed redundancy to allow regeneration while the linac operates. This was necessary to meet the APT availability requirement.

Power is supplied to the cavity through 12 waveguide irises (Figure IV). There are three 1-MW klystrons which will normally operate at 2/3 rated capacity. This will extend both rf window and klystron lifetimes. In the event of a klystron failure, the RFQ can operate with the remaining two klystrons.

FABRICATION STATUS

The RFQ cavity is being fabricated and brazed in the LANL shops. At the present time, three of the eight sections have been completed and machining of components of the remaining five sections is underway. High power commissioning is planned to begin in October 1998. A photo of Section A2 is shown in Figure V.

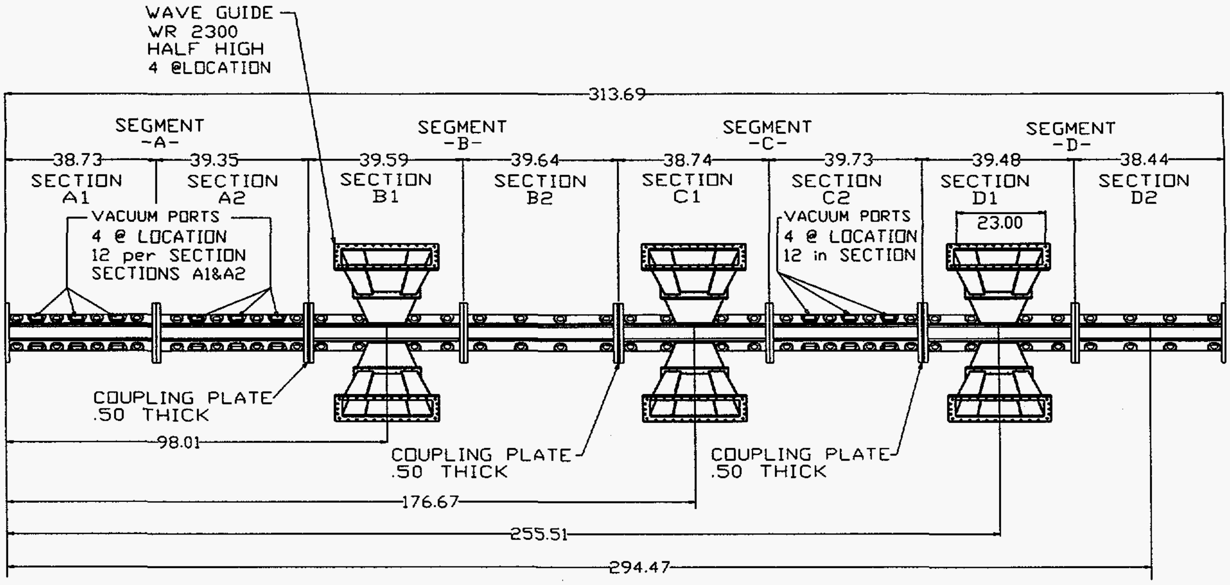

Figure IV: APT/LEDA RFQ Schematic

ACKNOWLEDGMENT

Other institutions participating in the RFQ project include LLNL (vacuum system) AlliedSignal (resonance control cooling system), and Northrop-Grumman (engineering support).

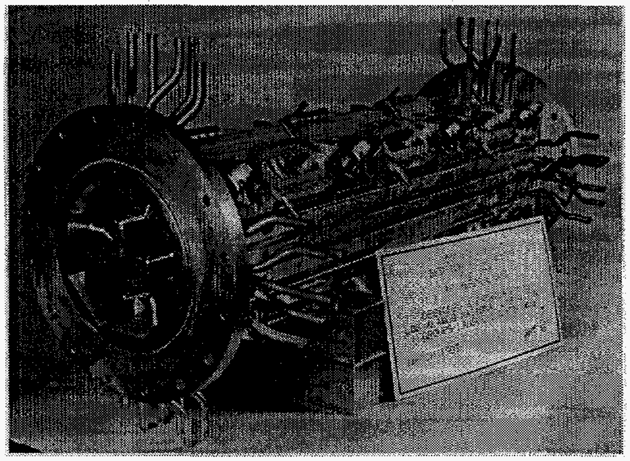

Figure V: APT/LEDA RFQ Section A2 After Furnace Brazing

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