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FMIT PROTOTYPE LINAC TANK*

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Summary

The prototype linac tank (PLT) is an assembly of many components. This paper is limited to a discussion of the shell, and not the attaching components. Basically, the shell consists of an 8-ft-diam by 12-ft-long copper-lined tube. Despite the simplicity of this description, many special features not used nor needed in pulsed accelerators have been incorporated into this design, to handle the continuous duty cycle and high radiation levels expected for the Fusion Materials Irradiation (FMIT) Facility.[1] The shell has been made a part of the development hardware package, not because the shell needed design development, but to allow testing and proving of other attaching hardware.

Introduction

The PLT (Fig. 1) is built to one-tenth the length of the FMIT and will be used at the Los Alamos National Laboratory to test the operation of the FMIT injector, the radio-frequency quadrupole (RFQ), and to train operators to handle FMIT systems. The operating characteristics of the molecular hydrogen beam, running through the PLT from 2 to 5 MeV, will create a milder radiation environment than FMIT.

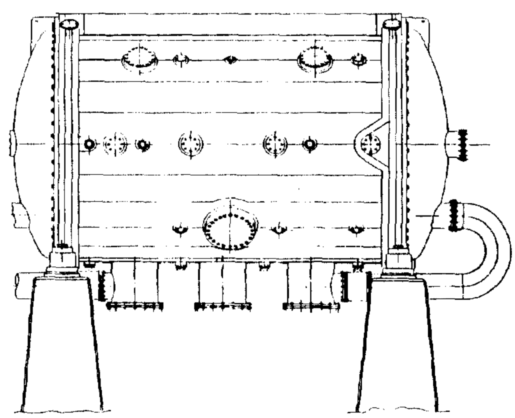

Fig. 1. Prototype linac tank.

Simplicity, high stiffness, adjustability, and reliability are the key words that describe the thrust of the PLT design effort. Functionally, the tank will operate at 80 MHz, with a vacuum of 10^{-6} Torr, with support-attaching subsystems weighing 31 000 lb, and with the capability to maintain its machined-in dimensional envelope to within 0.005 in. The PLT operating weight is 72 000 lb; its length is 144.65 in., and its nominal diameter is 96.50 in.

Scope

This paper presents a summary of the PLT's mechanical features; the categories are based on my opinion of what would be of general interest to others, should they consider designing a similar tank. These categories are tank cylinder, tank ports, cooling, alignment and leveling.

Note: As you read, periodically remind yourself, that FMIT is a continuous-duty-cycle machine with a 20-year service life, and with built-in high reliability. To achieve these operating conditions, six design rules were imposed on the PLT, with the intent of applying these rules also to FMIT.

- Use soft vacuum back-up for all seals and welds.
- Minimize high vacuum-to-water joints.
- Use welded RF joints (if possible).
- Provide copper lining on all port interiors.
- Use counterflow water cooling.
- Limit the use of copper plating and copper brazing.

Tank Cylinder

The tank is fabricated from ASTM A516 Grade-70 steel, explosively clad with copper. The clad copper makes up 20% of the composite, and conforms to ASME SB-152 Grade-102 requirements. The plate sizes ordered were 90 in. by 320 in. (100 in. is considered a maximum mill width). Two plates are welded together in the flat to make up the 149 in. tank length. The longitudinal seam is placed at the top of the tank, where most of the seam will be removed to make room for the spanner hatch frame. The circumference seam (Fig. 2) has an open soft-vacuum groove that isolates the copper welding from the steel, provides gas back-up for the copper and steel root passes, and allows a

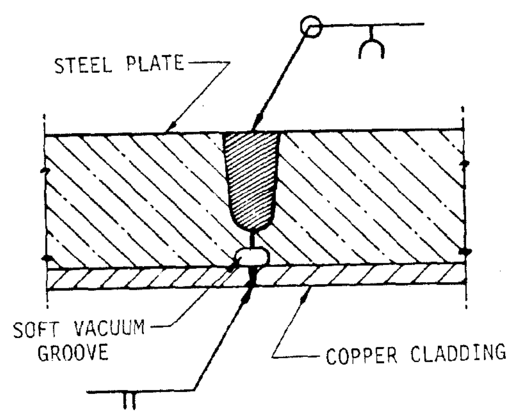

Fig. 2. Tank circumference weld seam.

simple way to helium-leak test the copper weld. Peening on the root and subsequent weld passes will control distortion. The volume of the cylinder is controlled by dimensioning the cylinder for circumference, not diameter. This circumference is 306.305, + 0.310, -0.000 in. Cylindricity is limited to 0.240, and the average diameter of 97.50/97.66 is verified by a least-squares analysis.

The average diameter verification is used as a manufacturing hold point during the two critical stages of manufacture; that is, after welding the hatch ports and stiffening rings to the cylinder, and after stress relief. To reduce the probability of

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reworking to meet the average diameter requirement, shrinkage tests, using samples from the clad-plate excess, have been specified.

Tank Ports

Three designs for the tank ports have been incorporated into the PLT. Each design has the common denominator of a copper lining. The first design is the most unusual in that it is 135 in. by 18 in. by 4 in. deep. Figure 3 shows a shipping

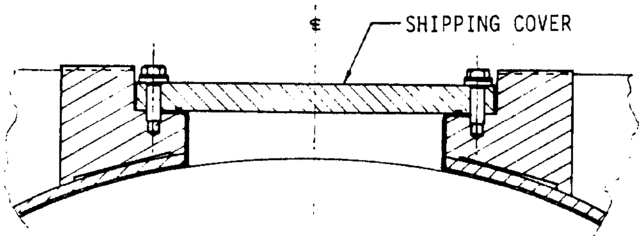

Fig. 3. Girder - drift-tube port.

cover closing the port. After tank installation, the drift-tube/girder assembly will be sealed to the hatch with a helicoflex metal/elastomer double seal to provide for RF current conduction and for soft vacuum back-up. The second design (Fig. 4) is for a

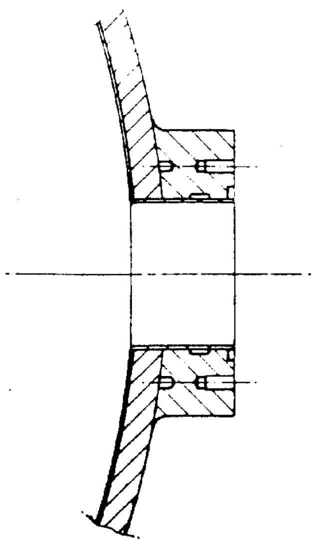

Fig. 4. Small port design.

majority of the small ports and uses a shrink-fit copper sleeve, welded in place. The flange is intended to provide the rigidity necessary when using metal seals. The final port design (Fig. 5), used for only the large vacuum piping, is copper plated before welding, and then is brush plated in the weld zone after the weld has been ground smooth.

For each of the three port designs, a machined center groove limits the amount of welding to that required by the ASME code and to maintain shell stiffness. The groove may be used, if needed, for auxiliary port cooling.

Cooling

No other feature of the PLT has received as much design attention as the cylinder and end-wall cooling.

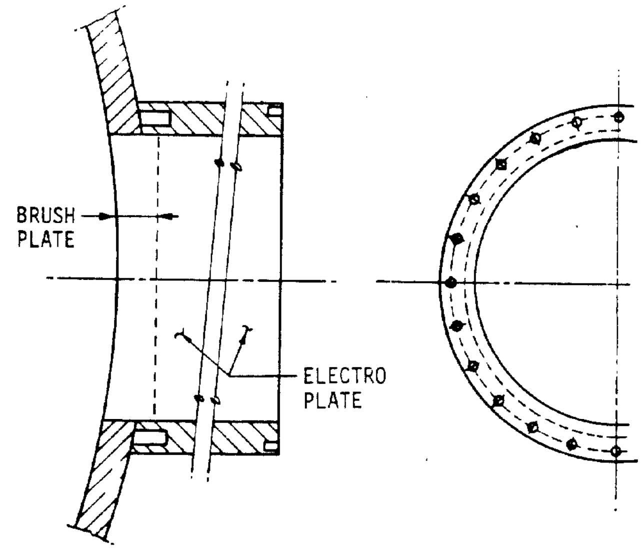

Fig. 5. Large port design.

Maintaining ±1°F wall temperatures requires large volumes of water, counterflow ducting, and complete water coverage. The cylinder cooling consists of 22 mirror-image channels placed around the tank outer surfaces. Manifolds at each end of the tank allow water to enter or exit by the system shown below (Fig. 6). The channels are of a dimpled-jacket design and are formed from 10-gauge alloy steel.

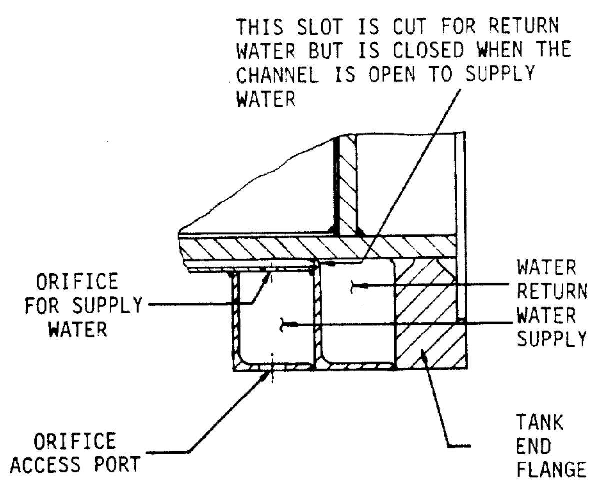

Fig. 6. Tank shell water system.

Channel flow is 21 gal/min at 10 psi with a velocity of 3 ft/s. Two drilled orifices maintain supply back pressure.

The end-wall cooling (Fig. 7) consists of 1-in.-diam copper tubes brazed to the steel side of the end wall in a way that provides for counterflow cooling. Supply and return access is through drilled passages in the end flanges. Tube flow is 34 gal/min at 8-ft/s. velocity. Cooling for the drift-tube shell is through conduction to the closely brazed water tubes. Note that the proper wall-to-drift-tube spacing (Fig. 8) is accomplished by deflecting the wall within its elastic range by mechanisms that are attached to the RFQ and energy-decay cavity (EDC).

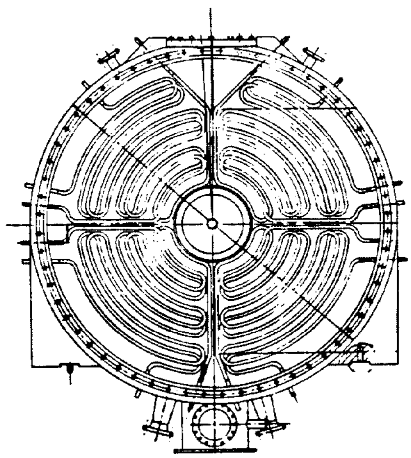

Fig. 7. Tank end-wall cooling.

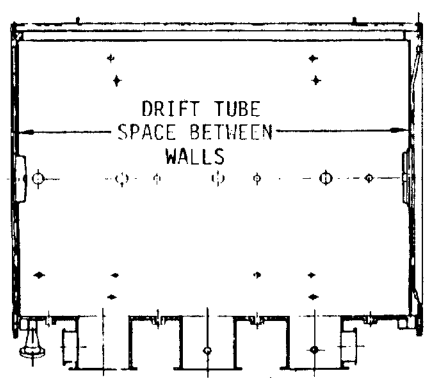

Fig. 8. Tank cross section.

The force required depends on the amount of deflection; but for the movements anticipated (±16 in.), the force will be ~ 500 lb applied near the center of the wall.

Alignment and Leveling

The tank rests on four concrete piers of a height to raise the tank centerline 10 ft above the floor. To adjust the tank into alignment with other components, four elevating jacks (coupled with hydrostatic pads) have been used. The hydrostatic pads handle a combined weight of 72 000 lb and will allow lateral and horizontal adjustment with a nominal 1/8-lb adjustment force. The nominal lift from the hydrostatic pads is 0.003 in.; at the point where adjustment is initiated, 21 ft/lb of torque will elevate each of the four jacks mounted on top of the hydrostatic pads (Fig. 9).

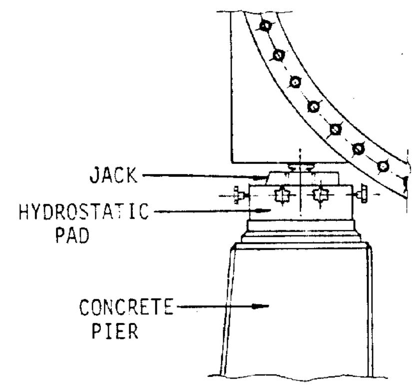

Fig. 9. Jack and pads on the support piers.

Tank alignment to other components is provided by the installation of tooling balls at two locations on both ends of the tank. These balls are placed within 0.005 in. of the average-tank centerline and have been used as the centerline location for all machining operations on the tank.

Acknowledgments

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1. E. L. Kemp, D. J. Liska and M. D. Machalek, "The Fusion Materials Irradiation Test (FMIT) Accelerator", Proc. 10th Linear Accelerator Conf., Montauk, New York, September 10-14, 1979 (Brookhaven National Laboratory, Upton, New York, 1980), BNL-51134.