IEEE Transactions on Nuclear Science, Vol. NS-30, No. 4, August 1983

ASSEMBLY AND INSTALLATION OF THE 2-MeV FMIT ACCELERATOR*

D. Liska and R. Michelotti, AT-4, MS H821
Los Alamos National Laboratory, Los Alamos, NM 87545

Summary

The front end of the 35-MeV Fusion Materials Irradiation Test (FMIT) Facility accelerator is being assembled and installed at Los Alamos. The machine ultimately will produce a 500-kW continuous duty beam at 5 Mev, although only the first 2-MeV will be installed this year. The 2-MeV system will include the most powerful radio frequency quadrupole (RFQ) in existence. The assembly and installation of the hardware are described, along with the unique problems arising from the large size and high power of the components involved.

A Design to Match FMIT Needs

A master plan exists at Los Alamos for a highly instrumented 5-MeV FMIT accelerator as shown in Fig. 1. The high-average FMIT beam current dictates the necessity of prototyping the front end of the machine, which consists of the injector, an RFQ, a short section of the drift-tube linac, and a high-energy beam transport (HEBT) with beamstop. All but the drift-tube-linac section of the system is being installed and will be operational by midyear. The facility is equipped to accommodate the full 5-MeV system as funding becomes available.

Without the drift-tube-linac section, an unusual opportunity to evaluate the RFQ as a stand-alone component is presented. With the diagnostics that are built into the injector/LEBT and the HEBT, an accurate assessment of the beam entering and exiting the RFQ can be made. Beam current, energy, emittance and loss can be measured as functions of beamline tune and also as functions of RFQ field levels. Thus, funding limitations are turned to advantage in studying an all-important component of FMIT at full power. The resulting 2-MeV installation is illustrated in Fig. 2 and has the following specifications:

Beam energy	2 MeV
Beam current	100 mA H_2^+
Power on beamstop	200 kW cw
Coolant flow	2640 gpm
RFQ parameters:	
Frequency	80 MHz
Current limit	205 mA
Input current	106 mA
Output current	100 mA
Radio-frequency power	491 kW
Length/diameter	408 cm/140 cm
Weight	11 364 kg
Beamline height	304.8 cm
Total length	16.5 m
Diagnostics	Noninterceptive

A key feature of the 2-MeV FMIT accelerator program at Los Alamos is that many of the components used eventually will be installed in the FMIT Facility at the Hanford Engineering Development Laboratory (HEDL) in Richland, Washington. The thrust of the Los Alamos program has been to design, install, and operate FMIT facility components. Thus the entire injector/LEBT and RFQ will be shipped to HEDL

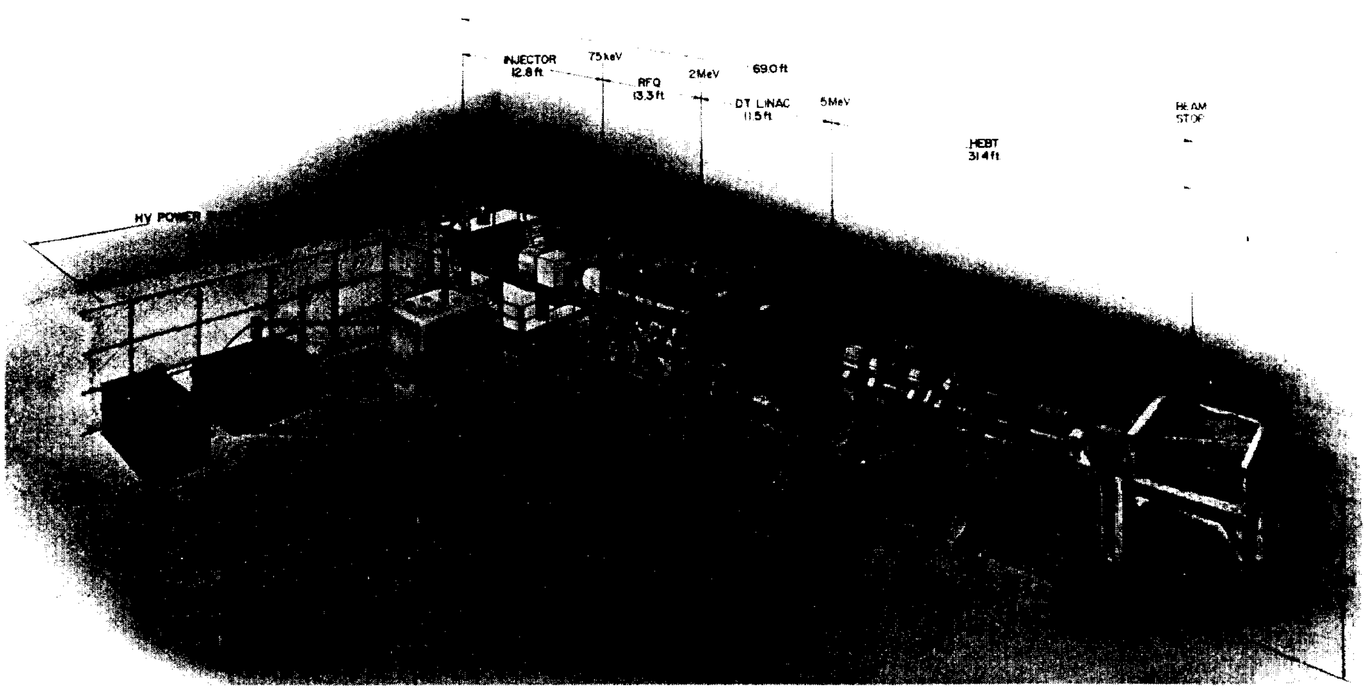

Fig. 1. The 5-MeV, 500-kW FMIT prototype accelerator.

*Work supported by the US Department of Energy.

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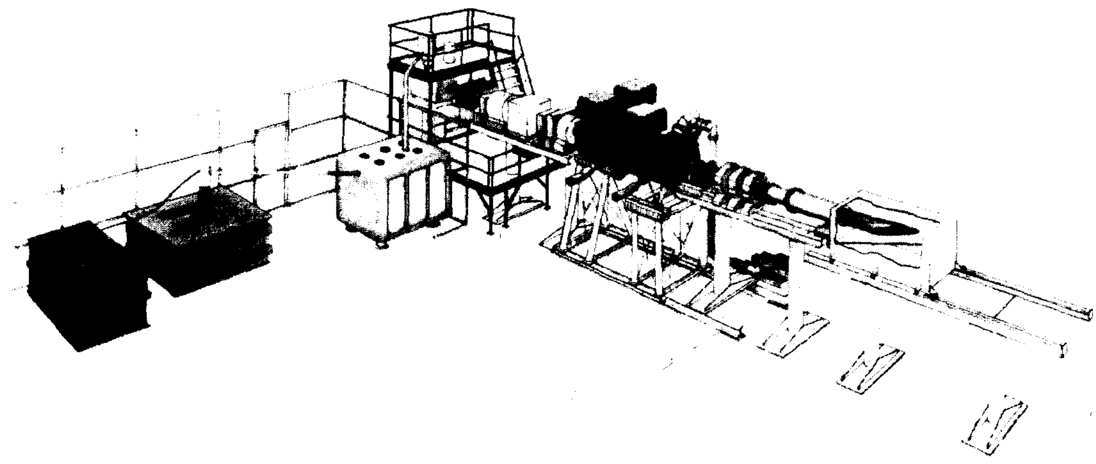

Fig. 2. The 2-MeV, 200-kW prototype accelerator.

following the conclusion of the program. In the HEBT, the quadrupoles and beamstop are both facility compatible. The drift-tube-linac tank, intended for use in the 5-MeV accelerator, is not compatible, although FMIT materials (copper-clad steel, etc.) and fabrication procedures have been used in designing the tank. Furthermore, the drift tubes and girder assembly, post couplers, slug tuner, rf drive loops, and vacuum hardware will be stripped off for shipment to HEDL. The rf system, including power amplifiers and transmission lines, also is FMIT facility hardware.

The components are large because of the 80-MHz operating frequency and have posed handling problems during assembly and installation.

Mini-HEBT

The RFQ's delivery schedule has slipped considerably while the HEBT components have held close to their design schedule. This combination of events has provided an opportunity for evaluating some of the HEBT components and characterizing the beam as it exits the LEBT. The first four HEBT quadrupoles and some beam-diagnostic devices were combined and assembled into the so-called "mini-HEBT" shown in Fig. 3. FMIT facility personnel have learned some valuable lessons from the operating experience of the mini-HEBT. Proper matching of the 75-keV injector beam into the RFQ requires solenoidal focusing at the LEBT/mini-HEBT interface. The strongly convergent beam that results will enter the RFQ's radial-matching section with a random distribution in X-X', Y-Y' phase space and a uniform distribution through 360° of phase. It will be efficiently captured by the RFQ with an $\sim$6% current loss, mostly injector-energy particles that lie outside the bucket. When the convergent beam enters the mini-HEBT beam tube, it undergoes a waist and essential emittance measurements are made. However, beyond the waist, the beam diverges and spills excessively along the beam tube walls that form an aperture of only 4.75 cm. This is not a problem when the beam tube and quadrupole module are placed downstream of the RFQ because the beam is parallel at this point. However, in the mini-HEBT, excessive beam losses required that a 0.75-mm sheath of copper be plated on the bore tube for better conduction into the cooling jacket. Then the copper was oxidized flat black to provide optimum background for viewing the glowing beam with low-level TV.

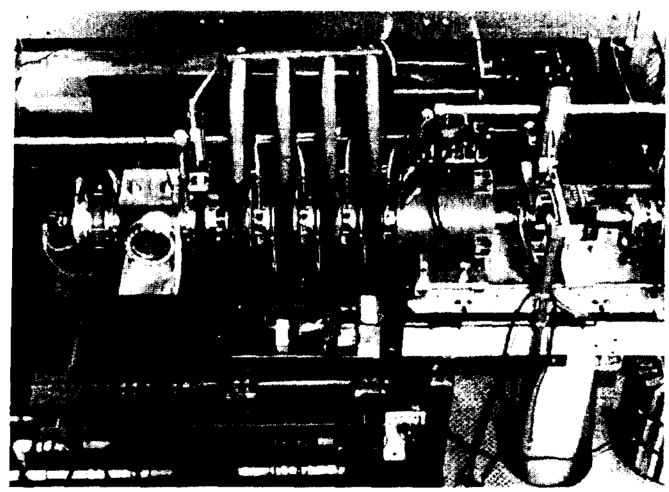

Fig. 3. Mini-HEBT for testing 75-keV injector beam.

Cooling H_2O

Approximately 17 x 10^6 BTUH of water-cooling capacity has been installed into the FMIT Development Facility. The system is designed to handle the 5-MeV accelerator at full power. All of the main feeder lines are copper or steel with all of the distribution system being polyvinyl chloride (PVC). Difficulties have been encountered with the PVC, but primarily the problems have been caused by faulty installation techniques. The situation has been improved significantly as personnel have become more familiar with the materials and the systems. PVC was used as a cost-saving device for a short-term facility but will not be used on the FMIT accelerator.

Alignment

All of the beamline components will be aligned to an off-line alignment plane. Bore alignment was precluded because of inaccessibility of the machine's bore. Where possible, components will be aligned in modules on a bench; the module then will be aligned on the beamline, thus reducing the number of alignment activities required on the beamline. This modular technique is critical to the maintenance of the FMIT accelerator. It is especially critical for the high-energy end because of concerns with activation. The mini-HEBT quadrupoles were installed using this technique with satisfactory results. For successful application of this technique, special attention must be given to the stiffness of the structure and to the clamping devices.

The rf Testing/Linac Tank

The 5-MeV linac tank was procured early in the program because it was a long-lead item. With the reorientation of the program from 5 to 2 MeV, the linac was no longer required as a part of the accelerator. A decision was made to install the linac tank in position for 5 MeV anyway. However, it would be limited for use only as a test load for the rf equipment as required for 2 MeV. A dummy drift tube was installed into the linac tank. It brought the tank frequency to within the range of the 80-MHz rf equipment. The tank has been used to develop the closed-loop high-power rf system and also will be used to develop simultaneous drive having two coupling loops at high power. All of the cooling and vacuum connections were designed for 5 MeV and were installed for rf evaluation. These connections will be removed at the conclusion of the rf testing and will be stored for reuse on 5 MeV if the funding becomes available. The tank and rf equipment installation is shown in Fig. 4. The ion pumps that were installed on the linac tank have not performed adequately; an ongoing program will investigate the cause of failure. This is an important evaluation because a similar design is intended for use on the 5-MeV and FMIT accelerators. Potential culprits are excessive hydrogen outgassing from the tank end walls or rf leakage into the pumps.

RFQ

The RFQ has not been received at the time of this writing. However, a tremendous effort has gone into the preparation of assembly and internal alignment hardware for the RFQ. The vanes, core tank, and manifold tank are roughly 4 m long and will be concentrically assembled and aligned in a horizontal orientation as shown in Fig. 5. The assembly, rf tuning, and installation of the RFQ are the critical path for turn on of the 2-MeV FMIT accelerator. The sheer weight and size of the RFQ present special installation problems, but the device has been built sturdy enough to withstand a great deal of handling. For instance, the RFQ vanes and tanks were built in New Mexico, the vane tips were machined in Pennsylvania, the copper plating done in Washington, the testing in New Mexico, and ultimately the RFQ will be shipped to HEDL.

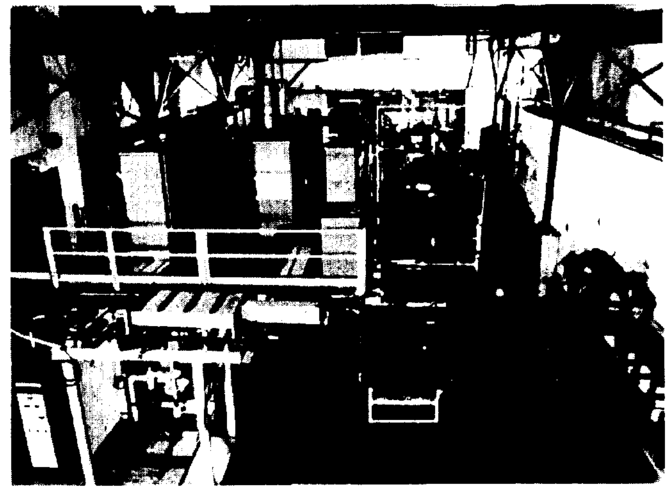

Fig. 4. The 5-MeV, 80-MHz test tank and rf drive system.

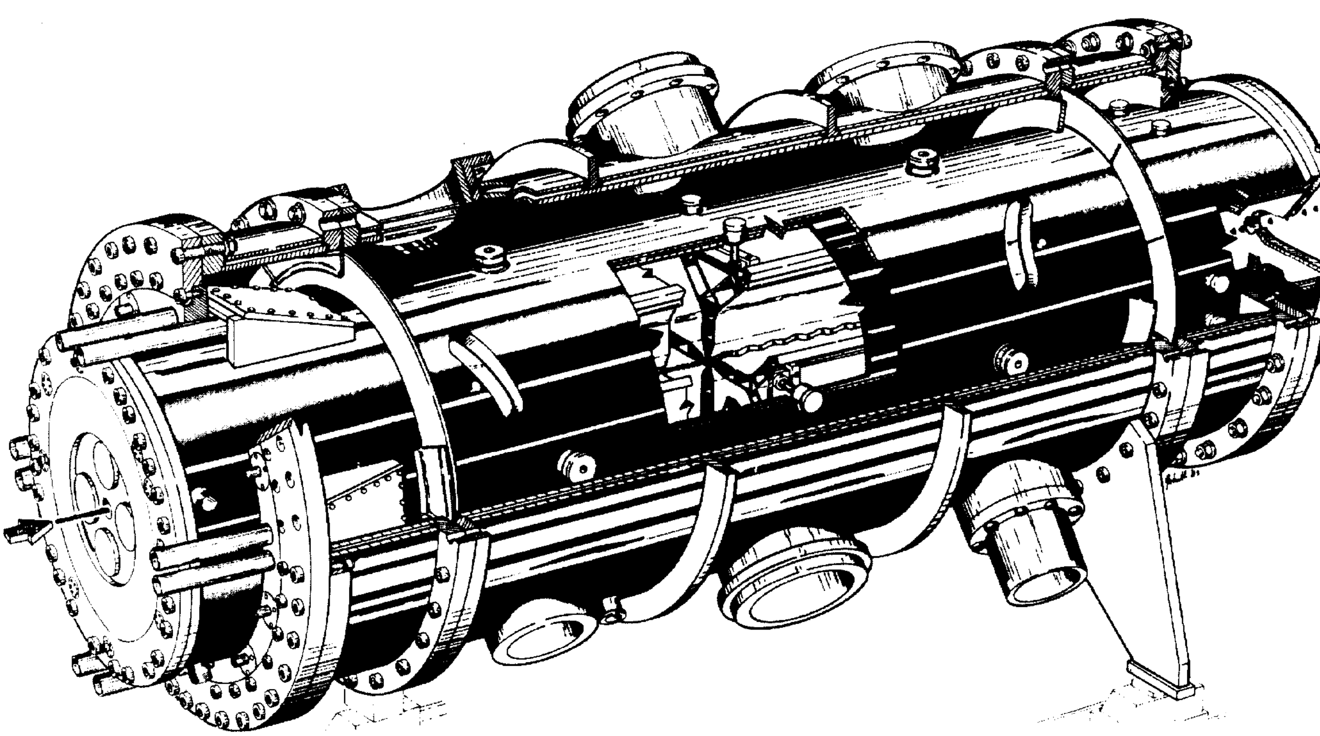

Fig. 5. FMIT RFQ assembly.