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ASSEMBLY AND HANDLING APPARATUS FOR
THE EBFA MARX GENERATOR

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ABSTRACT

Marx generators, a major slow-pulsed power component in Sandia Laboratories' Electron Beam Fusion Accelerator (EBFA), were assembled at a remote facility modified to utilize an assembly-line technique. Due to the size and weight of the various components, as well as the final Marx generator assembly, special handling apparatus was designed. Time and manpower constraints required that this assembly be done in parallel with the construction of the Electron Beam Fusion Facility (EBFF). The completed Marx generators were temporarily stored and then moved from the assembly building to the EBFF using special transportation racks designed specifically for this purpose.

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Introduction

The Marx generator is a major component of the slow-pulsed power system for Sandia Laboratories' Electron Beam Fusion Accelerator (EBFA). It is a power supply consisting of capacitors, switches, and resistors, assembled with appropriate plates, shielding, tubing, and hardware as shown in Figure 1. A facility has been provided with assembly-line procedures for production of the Marx generators, and it will also be used for temporary storage of the completed units. Facilities and equipment have also been provided to assemble and check out special resistors, and for leak testing the spark gap gas switches used on the Marx generators. A temporary machine shop was provided for minor modifications which may be necessary during assembly. To facilitate handling of the various heavy components during assembly, as well as facilitating handling of the final assembly, special apparatus was designed. Upon completion of the EBFA tank the completed Marx generators will be transported, in a special rack, from the assembly/storage location to the EBFA tank for installation.

Purpose

This report describes the mechanical design of equipment used to assemble and handle the EBFA Marx generators at a remote facility. Also described is equipment used to transport the assembled units from this assembly/storage facility to the accelerator for installation.

Design Procedure

In May 1977, discussions were held with various consultants in Department 4250 concerning the methods which were used to assemble Marx generators during the construction of the Proto I and Proto II accelerators. As a result of these discussions, basic design guidelines were established for the assembly and handling of Marx generators. The "plug-in" modular concept is a new design which makes the EBFA Marx generator unique. This concept dictates that the Marx generator must be handled as a unit that can be lifted into and out of an accelerator tank filled with transformer oil with a minimum of hardware, electrical, and plumbing connections.

Figure 1. Marx Generator in Storage Rack

Marx generators currently in use at Sandia are suspended from trolleys attached to I-beams which span the top of an accelerator tank (see Figure 2). The Marx generators were assembled in place under the I-beams in rows, then they were lifted with an overhead crane or forklift and attached to the trolleys. The trolleys permit lateral movement of the individual rows of each Marx unit prior to making the final electrical interconnections. After the rows are interconnected to complete the Marx generator, the entire unit can be moved laterally via the trolleys and I-beams. This movement, however, is restricted to the travel provided by the I-beam location and span. When a malfunction occurs in a Marx generator, repairs must be made while the unit is attached to the trolleys and suspended in the tank. If repairs cannot be made quickly, major disassembly of the unit is required thus necessitating long downtimes for the accelerator. To overcome these possible downtimes on the EBFA, especially since there will be 36 Marx generators in use thus greatly increasing the likelihood of failure, the Marx generator is designed to be handled as an assembly that can be quickly plugged in or removed from the EBFA tank, even when the tank is filled with transformer oil.

To provide the "plug-in" modular design feature, the Marx generator assemblies are attached to a lifting frame which permits the assembly to be handled as a unit (see Figure 3). Because the entire Marx generator can be lifted as an assembly, trolleys such as were needed to position the old Marx generators are not required. Locating and mounting features, which permit the

Marx generator to be suspended in the correct position by the lifting frame, are built into the EBFA tank (see Figure 4). Quick-disconnect features on the Marx generators include:

- Pressure contact switches for electrical connection from the Marx firing system to the high-voltage feedthrough and then to the intermediate storage capacitor located in the pulse-forming section (Figures 4 and 5)
- Fast-disconnect electrical connections for the charging lines
- Quick-release pressure fittings for the SF_6 insulating gas lines

When repairs are required, a Marx generator can be disconnected quickly and, using the overhead crane, it can be removed from the EBFA tank and deposited in a holding frame. The transformer oil can be drained before the entire Marx generator frame is moved to the maintenance area. A spare Marx generator can be installed quickly to replace the faulty generator which can then be repaired outside the tank, thereby minimizing downtimes for the generator.

Figure 2. Marx Generators Suspended from
Trolleys Attached to I-Beams

Figure 3. Marx Generator Subassembly

Figure 4. Marx Generator Transfer Switch

Figure 5. Current Monitoring Resistor

The capacitors used in the Marx generators are heavy (about 250 lb each) and therefore cannot be moved and positioned for manual assembly. Various capacitor subassemblies are also put together during the assembly process and must be moved and positioned for further assembly. Handling and lifting apparatus is designed to provide the capacitors and various subassemblies with features that would facilitate their being moved with an overhead crane. Lifting fixtures were designed for lifting one capacitor, a two-capacitor subassembly, a four-capacitor or column subassembly, and a row subassembly (see Figure 6). Prior to use, each lifting fixture was proof-tested by R. D. Jones, 9341, at the Static Test Lab in Area III. A load equal to 1.5 times the actual load was applied to each fixture for proof-testing. All test results were satisfactory and the fixtures revealed no permanent deformation after testing.

The completed Marx generators must be transported from the remote assembly area to the EBFA tank for installation. To safely transport the units, a special rack was designed (see Figure 7). This rack has features that permit the Marx unit to be suspended from the lifting frame as it would be in the EBFA tank. The lifting frame is then attached to the rack, and adjustable clamps which are part of the rack are positioned to secure the Marx units against sway during transport. The rack with the Marx generator is then lifted with a forklift and placed

on a tractor-trailer float for transportation to EBFA (see Figure 8). The Marx generators are removed from the rack at the EBFA site with the overhead crane and installed in the EBFA tank. This rack is also designed for storage of spare Marx units, and ladders provide access to generators in need of repair. A drip pan with a drain is also built into the rack's base for catching oil dripping from oily units removed from the EBFA tank.

Figure 6. Lifting Fixtures

Figure 7. Storage/Shipping Rack

Figure 8. Marx Generator being Lifted onto
Tractor-Trailer Float

An Air Force hangar, Building 481, located on Kirtland Air Force Base West, was being used as a heliostat assembly area for the Solar Thermal Test Facility project. In April 1977 a letter was written to Sandia Plant Engineering requesting that arrangements be made with the Air Force for the temporary use of Building 481 to assemble and store EBFA Marx generators, after the heliostat assembly was completed. When the request for use of Building 481 was approved, facility design layouts were prepared and reviewed by personnel in Division 4252 who would be responsible for the actual assembly of the Marx generators. Sandia Plant Engineering was then requested to have Building 481 modified as required for assembly of the Marx generators.

One room was modified to assemble and test the copper sulfate resistors used in the Marx generators. Deionized water was provided, as well as work benches for mixing the copper sulfate and for testing and storing the completed resistors. Another room was modified for leak testing the gas switches used on the Marx generators. Racks were provided for the safe storage of gas bottles used to pressurize the switches, and a special test tank was designed and fabricated to hold water and secure four switches for leak testing under water (see Figure 9). This room was provided with running water and a drain, as well as compressed air for drying switches after testing. A small machine shop was set up in another room in conjunction with another Sandia group which was also using Building 481. This shop is used for minor hardware modifications which may be required during assembly of the Marx generators.

Figure 9. Spark Gap Test System

An assembly line with gantry cranes and space to store temporarily the completed Marx generators was provided in the main hangar area (see Figure 10). Two A-frame gantry cranes, a 2-ton and a 5-ton model, were mounted on rails attached to the hangar floor. Work benches were provided outside of the crane rails to store small parts and mounting hardware used during assembly. Forklift access to the assembly line was provided to move and position the heavy components required during assembly. Electrical power was provided along the assembly line for power tools used during assembly. A fixture was designed which permits a complete Marx generator to be lifted and moved to the temporary storage area with a forklift.

Assembled Marx units are stored by setting them on the floor with special wooden spacers installed for supporting the lifting frames. After a Marx generator is positioned on the floor in the temporary storage location, it is covered with a specially made plastic bag to keep it clean during storage. Larger plastic bags keep the Marx generators clean while they are being transported from Building 481 to the EBFA site in specially designed transporter frames.

Figure 10. Assembly Line with Gantry Cranes

Conclusion

Facilities and hardware designed specifically for assembling and handling Marx generators allow the remote assembly of the generators prior to the completion of the EBFA tank. This allows optimum utilization of time and manpower committed to the assembly of the accelerator. The facility and handling equipment, with some minor modifications, is judged to be satisfactory for this remote assembly technique. The transportation of a complete Marx generator assembly from one facility to another is judged to be a satisfactory method for handling and removing Marx generators.