THE MAGNET TEST FACILITY
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An important part of the design and production of Energy Saver magnets has been the Magnet Test Facility located in Industrial Buildings 1 and 3. Every Energy Saver dipole and quadrupole must pass an exacting series of tests in the Magnet Test Facility before it can be installed in the ring.

It is not unusual to test accelerator magnets before they are installed, but superconducting magnets have features that make the testing more necessary but at the same time more laborious. In conventional magnets, the variation of the magnetic field with distance is almost completely determined by the shape of the steel magnet poles. In superconducting magnets like those of the Energy Saver, the steel has only secondary effects on the field, which is largely determined by the placement of the superconducting coils. This gives a field rich in harmonics higher than the desired dipole or quadrupole, so careful measurements are necessary to determine whether these harmonics are within acceptable limits. In the case of the Energy Saver, these limits on field quality are made more stringent by the fact that the ring will be used as a storage ring. Protons and antiprotons will stay in the ring for times much longer than in a mere accelerator, and this places tighter requirements on the field.

In addition, the time scale of testing is much longer for superconducting magnets, because some hours are needed for hooking up the complex cryogenic leads and cooling the magnet down to its operating temperature, 4.6°K above absolute zero. The total of the cooling, measurement, and warmup times means that every one of the 1150 production Energy Saver magnets and approximately 150 magnets built during the earlier design and development phase has spent at least 24 hours on a test stand at the Magnet Test Facility. (Some have spent much longer. During the course of the measurements of cryostat motion that led to the smart bolts, one magnet spent more than 4 weeks in continuous testing.)

Even before the completed magnets undergo their cold tests, the field of the collared coils is measured at room temperature with low current in IB3. This first look at the harmonics has the purpose of finding any defects in coil winding and fixing them before the coil is installed in a cryostat and yoke, a process not easily reversed.

There are six test stands in MTF, four for dipoles and two for quadrupoles. A 1500 W helium refrigerator with a 10,000 l helium storage tank provides the cooling capability. A test stand holds only one magnet at a time and the helium flow must be
turned around in an "end box" similar to the "turn-around box" at the end of a magnet string in the tunnel.

A magnet is placed on the stand, connected cryogenically and electrically, vacuum pumped, and cooled down in approximately 6 hours. The Energy Saver is a cold-bore design, so an insulated pipe must be installed in the bore of the beam pipe to make it accessible for measurements. The magnet is then "trained" by ramping it up to a field at which it "quenches," that is, it stops being superconducting. The energy in the field must be dissipated at this point. It boils the helium, which is recovered and recooled. Energy Saver dipoles require at most one or two training ramps to reach the design field, quadrupoles typically exceed the design field before quenching.

When training is done, the magnetic field is measured in a number of detailed ways. The integral field and its vertical plane are measured with a long loop. The centerline field is measured along the magnet in detail by a nuclear magnetic resonance probe. The field harmonics are measured in a series of three measurements, because the rotating coil probe is not long enough to do a 20 ft dipole in one shot. For a quadrupole, an additional measurement must be made to determine the field center. Following a successful cold test, a magnet undergoes extensive mechanical measurements to ensure that adjacent magnets will fit together in the ring.

These data are summarized and reviewed by Energy Saver people. The data are used partly to determine the optimum location for the magnet in the ring, because undesirable harmonics can be partly cancelled in neighboring magnets. This lengthy measurement and acceptance process has now been done on over 90% of the Energy Saver magnets. The production measurement accomplishment represents an intensive around-the-clock operation by some 65 technicians and physicists for the past two years.

Many people have contributed to the design and development of MTF. It was conceived and begun by Ryuji Yamada in 1977. Technical work of great importance was done by Dan Gross. Masyochi Wake of KEK made important contributions during his sabbatical year here. Frank Cole led the department through the completion of all six stands and of the measurements leading to an acceptable dipole. Frank Nozrick led through a large part of making MTF into a mass-production facility. Over the past several years, Ray Hanft, Bill Cooper, and Marvin Johnson have played major roles in running the MTF operation. Many other people, too numerous to mention, have worked to carry through this exacting task. All these people can feel pride in their participation in a vital part of the building of the Energy Saver.