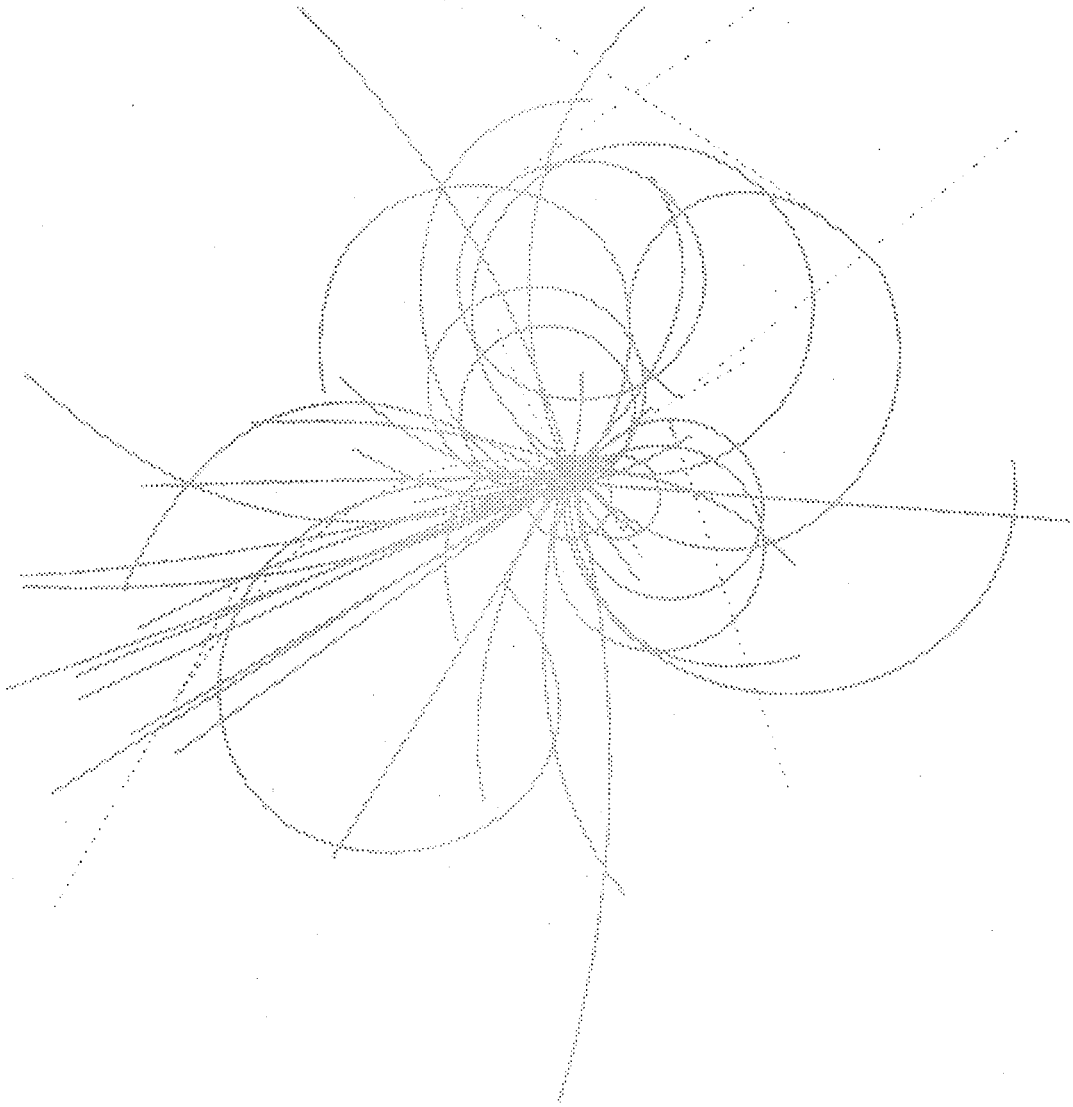
SSCL-Preprint-44

SSCL-Preprint-44

Superconducting Super Collider Laboratory



A Facility Description of the SSCL Magnet Test Laboratory

M. Coles

March 1992

To be published in *Supercollider 4*

SSCL-Preprint-44

A Facility Description of the SSCL Magnet Test Laboratory*

M. Coles

Superconducting Super Collider Laboratory†
2550 Beckleymeade Ave.
Dallas, TX 75237

March 1992

*Presented at the International Industrial Symposium on the Super Collider, New Orleans, March 4–6, 1992.

†Operated by the Universities Research Association, Inc., for the U.S. Department of Energy under Contract No. DE-AC35-89ER40486.

A FACILITY DESCRIPTION OF THE SSCL MAGNET TEST LABORATORY

Mark W. Coles

Magnet Systems Division
Superconducting Super Collider Laboratory*
2550 Beckleymeade Ave.
Dallas, Texas 75237

INTRODUCTION

The Magnet Test Laboratory (MTL) at the Superconducting Super Collider Laboratory (SSCL), presently under construction at the N15 site west of Waxahachie, will be used to cold test superconducting magnets prior to their installation in the high energy booster (HEB) and the main ring of the collider. This paper describes this facility, the activities and apparatus planned for use within it, and the schedule for completion and phasing in of the operating facility. More detailed information regarding the physical facility and its functional requirements is given in References 1 and 2. Additional references are given within this paper to apparatus that has been designed for use in the MTL and that may be of interest to those building similar facilities.

Properties of superconducting magnets will be tested in resistive and superconducting states. Ten single-magnet cold test stands, a three-magnet string test area, and a vertical dewar test area will all be installed within the MTL. Eight of the single-magnet cold test stands are intended for production testing, while the remaining facilities are more heavily instrumented and are intended for detailed research investigations of superconducting magnets, cable, and wire. It is anticipated that the MTL will have a production test rate of between one and two magnets per day. (Asymptotically, roughly 10% of all magnets provided by vendors and 100% of all magnets built by the SSCL will be cold tested.)

Typical warm magnet tests to be performed in the MTL include hi-potting, electrical continuity check, test of electrical isolation turn-to-turn and conductor to cryostat, check of alignment of the beam tube and the magnetic field with respect to magnet fiducials, measurement of the magnetic field harmonics at low current, and measurement of coil prestress. Warm testing within the MTL will be conducted only on magnets that are also scheduled for cold testing; routine warm tests for all magnets are planned for the proposed Magnet Inspection and Storage Facility (MISF). Typical production cold testing activities will be vacuum testing, verification of the electrical isolation of the conductor when a

*Operated by the Universities Research Association, Inc, for the U. S. Department of Energy under Contract No. DE-AC35-89ER40486.

magnet is cold, verification of the operation of the quench heaters, quench testing, measurement of field characteristics at constant current, fundamental field angle orientation (field angle for dipoles, field angle and center for quadrupoles), and integral product of field times length. More detailed R&D activities planned for the single magnet test stands are quench evolution and propagation studies, measurement of stress due to Lorentz forces, determination of magnetic field characteristics at various operating currents and temperatures from 2.5 K to 4.5 K, determination of detailed quench characteristics (critical current, quench initiation location, propagation velocity, etc.) as a function of temperature, and time-dependent field measurements. Similar activities will also be carried out on short test magnets in the vertical dewar facility. The string test studies will include repetitive thermal and power cycling, heat load tests, evaluation of magnet interconnect performance, and quench studies.

In general, production magnet tests in the MTL will be done to determine systematic or process-dependent performance characteristics. Random defects (shipping damage, dimensional tolerance, workmanship errors, etc.) will be identified through testing in the MISF. Figure 1 shows the anticipated magnet flow into and out of the MTL. It is anticipated that all magnets delivered to the MTL will arrive from the MISF, and all production magnets exiting the MTL will return to the MISF. It is presently proposed that the MISF be constructed adjacent to the MTL. Anticipated flow of magnets within the MTL is shown in Figure 2. Common bridge crane coverage of the cold test floor area, warm test area, and the cable and vertical test area simplifies circulation of magnets from the receiving area. The bridge crane has a 25-ton lift capacity and a 20-ft hook height.

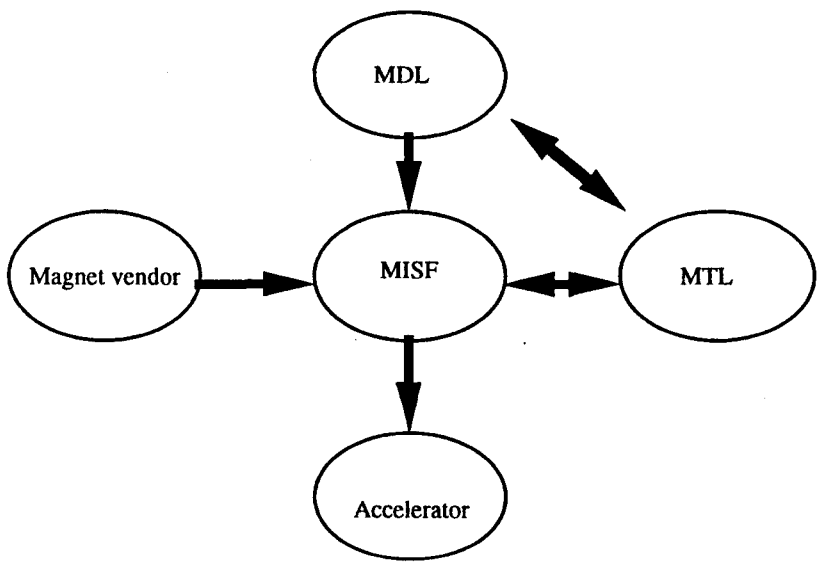


Figure 1. Flow of magnets to be tested in the Magnet Test Laboratory.

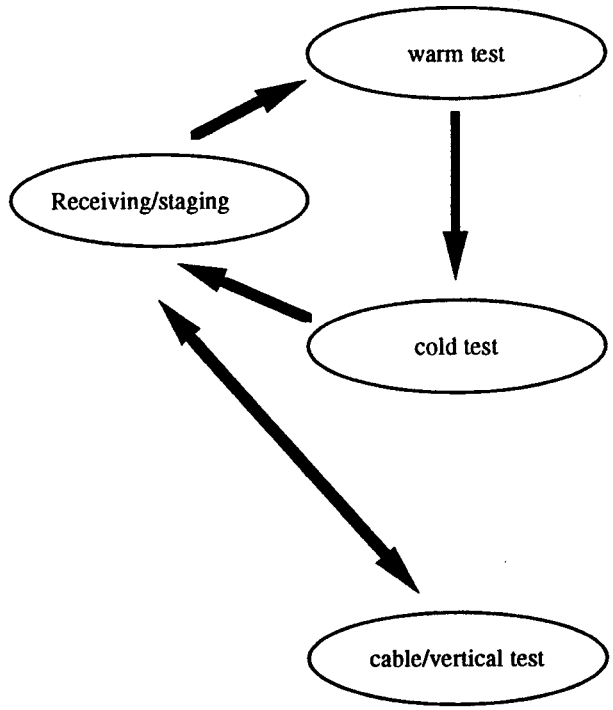


Figure 2. Flow of magnets and cable samples through the MTL.

FACILITIES DESCRIPTION

The floor plan of the MTL is shown in Figure 3. The warm test areas, on either side of the central cold test area, provide space to determine warm measurements as part of the study of warm-cold correlations in magnet behavior. Of special interest are correlations between warm and cold magnetic multipole measurements. Since the fields being measured are so small, power provided to this area is well isolated from the high-current DC power supplies and various motor power requirements of the MTL.

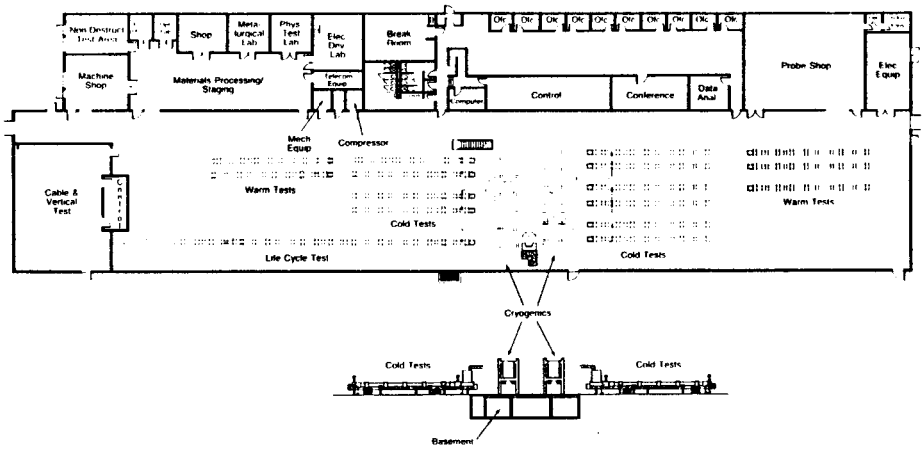


Figure 3. Floor plan of Magnet Test Laboratory showing layout of magnet test stands and central cryogenic distribution boxes.

The cold test area, in the center of the high bay, is clustered around the central cryogenic distribution box mezzanine. Cryogens enter each magnet from the distribution box through the feed end, flow through the magnet to the turn-around end can, then return through the magnet to the feed can and into the refrigerator room. Additional space is provided near the end of each test bench in order to insert a measurement probe and to transport it through a magnet. This requires approximately 10 ft beyond the turn-around end can and about 5 ft beyond the feed can end. Vacuum pumps and the magnetic measurement data acquisition electronics will be located on cars that can be rolled from stand to stand.

Power supplies for the single-magnet cold test are located in the basement under the cryogenic mezzanine, within the central area of the high bay. Seven power supplies are shared among the ten single-magnet stands and the three-magnet string. There are dedicated supplies for the R&D test stands and the three-magnet string; the eight production stands share the remaining four supplies. At least one of the supplies provides an output of 8000 A at 40 VDC; the remaining power supplies will be rated at 10,000 A. (Recent advances in the performance of the superconducting cable have necessitated the high current rating in order to conduct quench studies at temperatures in the region of 2.5–3.5 K.) The 8000 A power supply specification is given in Reference 3. Power to the production stands is routed through link boxes that manually switch the power from one stand to another. Two of the production test power supplies are also equipped with reversing switches for use with HEB magnets. The reversing switches are also connected via link boxes. (Details of the link box design are given in Reference 4.) Also located in the basement are the dump switches. Water-cooled buswork connects the link boxes to the power leads in the magnet feed cans. Use of a basement to house this equipment allows the test floor to be clean and free of overhanging wires and cabling that would otherwise interfere with rapid installation and removal of a magnet under test. Note that the basement has an access hatch so that the power supplies may be installed and removed using the overhead bridge crane.

The feed can, the magnet under test, and the turnaround end can all sit on a cold test stand. (Specifications for the feed can and the turnaround end can are given in References 6 and 7, respectively.) These stands, located on either side of the cryogenic distribution box mezzanine, are interleaved so that a long (approximately 22 m) warm bore may be inserted in either end of a magnet prior to cooldown when it is needed to make magnetic measurements. Also, the stands are spaced so that there are alternating wide (12 ft) and narrow (8 ft) aisles on each side of each magnet. (Details of the cold test stand design are given in Reference 5.) The test stand is designed to accommodate all anticipated magnet

lengths. The data acquisition electronics are located underneath the cold test stands in portable racks (so they can be moved when magnets of different lengths are tested). Details of this equipment (isolation amplifiers, MVME147 single board computers, data loggers, strain, cryogenic sensor readout electronics, quench detection electronics, UPS backup for the quench detection system, and the heater firing units) are given in Reference 8. It is anticipated that all data-acquisition electronics will be located in the immediate vicinity of the cold and warm test stands. Only digital lines will connect the test floor to the MTL control room. Trenches located in the floor of the high bay separately conduct conditioned and unconditioned power, digital, and other communication lines to the individual test stands and to the power supply controls in the basement.

Within the control room are 11 individual workstations for controlling each cold test stand and the three-magnet string. Warm test area activities will not be controlled from the control room. The software architecture used for data acquisition and control (see Reference 9) allows any workstation to control any test stand, including the regulation of the flow of cryogens through the feed can and into each magnet. A separate console for control of the refrigeration system is also provided. The other workstations do not control the internal operation of the refrigerator.

Workstations will be linked via Ethernet to the local area network (LAN), which is also connected to the data acquisition processors, the file server, and a LAN router. A window in the control room provides a limited view of the high bay. Supplemental TV-camera coverage will be used as necessary. The control room has a raised floor in order to facilitate cable routing.

The computer room will house two file servers and the LAN router. A "jukebox" disk storage system and a UPS power supply will also be located in this room. One file server will archive all warm and cold magnet test data; the other will handle instrumentation calibration information and system configuration data.

The probe shop will be a testing, maintenance, and calibration laboratory for magnetic field measuring probes. All probes used to determine the quality of the magnets will be calibrated and certified in this lab prior to their use on the magnets. Probe development and enhancements will be performed in this facility. The probe shop will also be used for normal electronic instrumentation support and development activities associated with the magnet test operations. Magnetic multipole measurement equipment supplied to the magnet subcontractors will be periodically recalibrated here.

The cable and short-magnet test area will contain two short-magnet test dewars, one cable test dewar, one wire test dewar, and one pre-cool dewar. The magnet test dewar, the wire test dewar, and the cable test dewar may operate simultaneously. Sufficient space is available to add more short-magnet test dewars if circumstances later require it. A jib crane, covering the entire dewar test area, will be used to lift and insert short magnets into dewars. The short-magnet test area has a dedicated data acquisition system and a file server that is separate from that of the long-magnet test facility. The short-magnet control room is exclusively for this area and will provide four control and data display stations. Any one of the control stations will be able to run an experiment at any one of the vertical dewars. Space is provided adjacent to the dewars for staging of the magnets and test samples. The dewars will have access to liquid helium supplied at atmospheric pressure from the MTL refrigerator.

Data acquisition and control electronics are located in racks directly behind the dewars. The facility will contain four 10,000-A bipolar power supplies. There will also be one 15,000-A supply. (Details regarding these supplies can be found in Reference 10.) In addition to the supplies, there will be four energy dump systems that will each contain an SCR circuit to remove energy from a magnet.

Engineering labs in the MTL will be used to study the material properties of superconducting cable. Individual areas will be dedicated to physical testing, non-

destructive testing, a metallurgical laboratory, a scanning electron microscope room, and an optical lab. A small machine shop area will be provided to support maintenance and installation activities within the MTL. An instrument repair shop (for maintenance of electronic equipment) is also located within the MTL. Individual office space will be provided for 30 people. The total population of the MTL (the sum of all three shifts) will be approximately 100 people.

The refrigerator compressor is located in a separate, sound-isolated building abutting the Accelerator Systems String Test (ASST) compressor building. The cold box room abuts the MTL high bay to limit the length of the transfer lines that run from the cold box to the distribution boxes. The refrigerator[11] can supply 2000 W of refrigeration while liquefying 20 g/sec of liquid helium at a combined flow rate of 500 g/sec to the magnets under test.

Other important infrastructure features of the MTL are the low-conductivity cooling water supplied to the long and short magnet power supplies and to the calibration magnet in the probe shop (approximately 300 gpm), the 25-ton bridge crane that provides coverage of the entire high bay, oxygen-deficiency hazard monitoring through the high bay area, and the provision of transformer-isolated instrument power in order to facilitate very sensitive electrical measurements.

It is possible that the cold test capability of the MTL could be expanded. The optimal level of production sampling will be determined dynamically through sampling statistics accumulated during production experience. Expansion, if required, will occur to the west of the high bay. The layout of the present building facilitates expansion through the implementation in the design of two access doors, bridge crane motion in the direction of expansion, easy conversion of the conference room to additional control room space, and adjacency of the ASST and N15 refrigerators so that additional refrigeration capacity could be added if required.

DEVELOPMENT PLANS

The principal milestones for completion of MTL construction are given in Table 1. First cooldown of a long magnet will be early in 1993, following the commissioning of the MTL refrigerator. Initially, the MTL will have only a single cryogenic distribution manifold with five distribution boxes, two cold test stands, and a single 8000-A power supply. Once these equipment items are evaluated, additional instrumentation will be procured so that four single-magnet test stands and the three-magnet string test will be operational in the second half of 1993. The additional six distribution boxes will be procured for delivery in 1994.

Table 1. Construction and cryogenic refrigerator installation milestones for the Magnet Test Laboratory.

Activity	Description	Start	Finish
Design	Title I (30%), Value Engineering	1/91	3/91
CCB	Change Control	3/91	4/91
Design	Title II (100%)	5/91	8/91
Procurement	Award–foundations	12/91	12/24/91
Construction	Pit and drilled piers	1/92	2/20/92
Procurement	Award–general buildings	1/92	2/5/92
Construction	MTL steel erection	3/92	5/92
Construction	MTL building enclosed	5/92	6/92
Construction	MTL substantial completion*		7/31/92
Construction	MTL subcontract completion		8/31/92
Construction	Compressor bldg. steel erection	2/92	4/3/92
Construction	Compressor partial beneficial occupancy		4/30/92
Construction	Compressor substantial completion		5/15/92
Construction	Refrigerator bldg. steel erection	2/92	3/15/92
Construction	Cold box installation	3/16/92	3/22/92
Construction	Refrigerator bldg. partial BOD		4/15/92
Construction	Refrigerator bldg. substantial completion		4/30/92

*High bay and low bay control room, computer room, and electrical equipment room may be utilized for their intended purposes at this time.

REFERENCES

1. A-E/CM Work package authorization for the Magnet Test Laboratory and Compressor Building, SSC Control No. C42-000003.
2. Contract documents, Issue for Bid (IFB) set of 13 Dec., 1991 for the MTL, PB/MK document control No. CPB-001068. This may be purchased from PB/MK with SSCL approval. These documents are also available for reference through SSCL document control.
3. Specification for a 40 Volt, 8000 Amp DC power supply for the Magnet Test Laboratory, SSC Control No. A40-000001.
4. Linkbox 2A, part no. M60-000953, and Linkbox 2B, part no. M60-000962.
5. MTL Cold Test stand, part no. M60-000901.
6. Feed Can Equipment Specification, SSC Control No. M62-000025.
7. End Can Equipment Specification, SSC Control No. M62-000034.
8. Electrical Instrumentation for Cold Test of SSC Magnets, J.E. Dryer and Y. Liu, presentation IX-4 of these proceedings.
9. Software Design Philosophy for the SSCL Magnet Test Laboratory, P.A. Craker et al., presentation IX-25 of these proceedings.
10. Specification for a 6 VDC, 15,000 Amp Power Supply, SSC Control No. M30-000400, and Specification for a ±10,000 Amp ±12VDC Power Supply, SSC Control No. M30-000294.
11. Refrigerator Specification—Request for Proposal, MTL Cryogenic System, RFP No. SSC-90-A-01107.