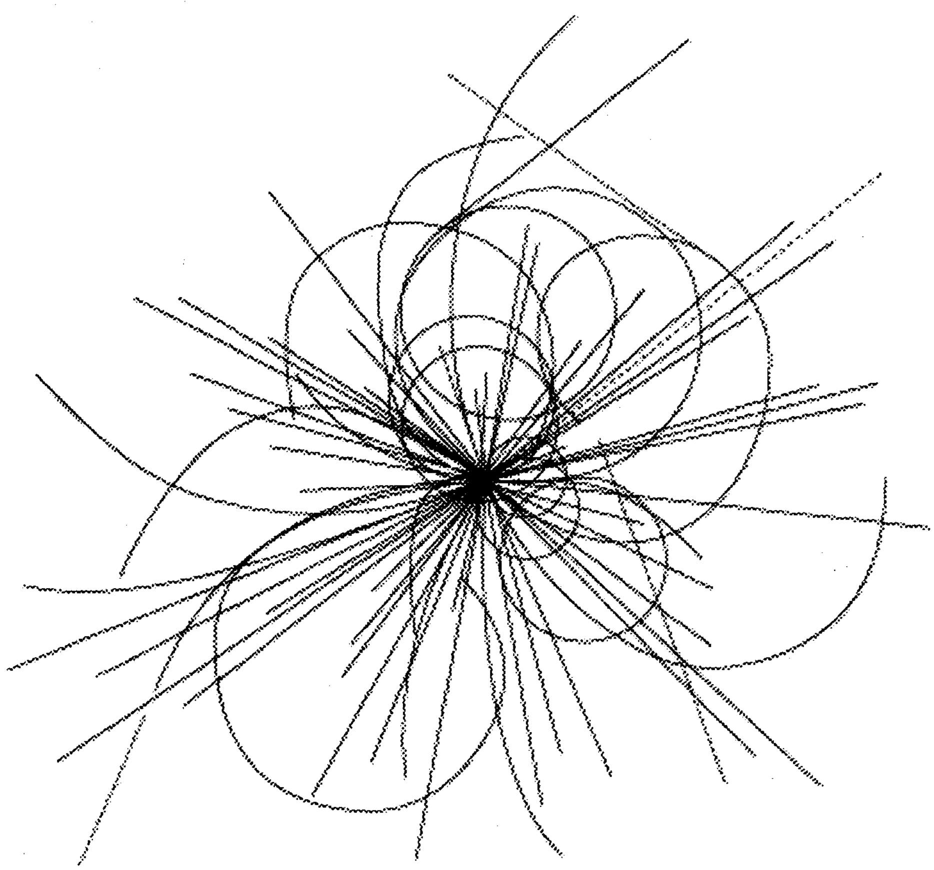
Conf-930511--523

SSCL-Preprint-431

SSCL-Preprint-431
May 1993
Distribution Category: 400

P. Kraushaar
W. Burgett
T. Dombeck
A. McInturff
W. Robinson
V. Saladin

SSC String Test Facility for Superconducting Magnets: Testing Capabilities and Program for Collider Magnets



Superconducting Super Collider Laboratory

SSCL-Preprint-431

SSC String Test Facility for Superconducting Magnets: Testing Capabilities and Program for Collider Magnets*

P. Kraushaar, W. Burgett, T. Dombeck,
A. McInturff, W. Robinson, and V. Saladin

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

May 1993

DISCLAIMER

*Presented at the 1993 IEEE Particle Accelerator Conference on May 17–20, Washington, D.C.
†Operated by the Universities Research Association, Inc., for the U.S. Department of Energy under Contract No. DE-AC35-89ER40486.

SSC String Test Facility for Superconducting Magnets: Testing Capabilities and Program for Collider Magnets

P. Kraushaar, W. Burgett, T. Dombeck, A. McInturff, W. Robinson and V. Saladin
Superconducting Super Collider Laboratory*
2550 Beckleymeade Ave., Dallas, TX 75237

Abstract

The Accelerator Systems String Test (ASST) R&D Testing Facility has been established at the SSC Laboratory to test Collider and High Energy Booster (HEB) superconducting magnet strings. The facility is operational and has had two testing periods utilizing a half cell of collider prototypical magnets with the associated spool pieces and support systems. This paper presents a description of the testing capabilities of the facility with respect to components and supporting subsystems (cryogenic, power, quench protection, controls and instrumentation), the planned testing program for the collider magnets.

I. INTRODUCTION

The Superconducting Super Collider Laboratory (SSCL) constructed a magnet string testing complex at the laboratory's N15 site in order to fulfill a Congressionally mandated milestone for the project. This milestone was to demonstrate the operation of a half-cell of the Collider lattice under full power conditions. The half-cell tested consisted of five 15 meter, 50 mm aperture dipoles, one 40 mm aperture quadrupole and the necessary spool pieces. This task was successfully completed in August, 1992, when the string was ramped to 6520 amps, six weeks ahead of schedule. The results of this first test run and a discussion of the milestone objectives occurs in reference [1].

The milestone completion marked a transition point in the mission of the ASST facility and the management structure it operated under. The SSCL utilized a task force organization for the milestone effort and once completed, the task force dissolved. Prior to this, a planning effort was started to prepare for the transition of the ASST to testing facility for superconducting accelerator lattice components. The motivation for the organizational structure adopted was simple. The SSC Laboratory required a facility where technical components could be integrated into collider prototypical systems and subsystems for testing and operation. Without this capability, the SSCL could not meet the quality assurance goals stated for the Collider Project. Test verification of the two superconducting accelerator's, (Collider and the High Energy Booster (HEB), level 3B specifications is required [2,3]. Besides providing a facility for system testing and personnel training, the ASST test program needed to provide for the measurement of critical component parameters that could not be verified in single component testing. Two examples of this would be the heat leak to the 4K cryogenic circuit for collider magnets and the response of spool piece components to magnet quenches.

The Collider Machine Group assumed the responsibility for the program management and the initial operation of the ASST. The ASST Test Group was formed from members of the Collider Machine Group and the Project Management Office (PMO) who participated in the milestone effort, and the support personnel from the ASST Task Force [4].

II. THE ASST SYSTEMS CAPABILITIES

The ASST complex consists of the ASST string, the refrigerator, the magnet power supply and the refrigerator compressor buildings. The last three areas are part of the N15 Utility complex that will serve the Collider when in operation. The ASST building consists of a large, 29 m by 9.8 m laydown area for the receiving and checkout of string components, and the magnet string enclosure which is 200 m long and 5.2 m wide. The string enclosure was built with the same curvature as the Collider tunnel. A niche area is provided to contain the quench protection system and other test electronics. Located adjacent to the niche are two trailers, each 5.5 m by 18.3 m. One is configured to provide office space for technical personnel and the other serves as the ASST control room. The remote operation of the string subsystems and the monitoring of the technical components under test is accomplished from this control room. These systems include cryogenics, magnet power, quench protection (QPS), controls (data acquisition and process), and safety.

The initial cyrogenics system for the ASST was built around a small 550 watt helium refrigerator (Plan B) which could provide 135 l/hr of liquid helium. This system delivered 50 g/s mass flow of helium to the string [7]. The Plan B refrigerator was adequate to cool and operate a half-cell string and was purchased as a backup to the primary refrigerator, Plan A. Plan B was used in Runs 1 and 2 when the primary system was delayed. The Plan B refrigerator has been removed from the ASST and will be used at the SSCL's Central Facility as part of the spool piece test stand.

The Plan A refrigerator has been commissioned and will support the ASST program from now on. This refrigerator is part of the N15 Arc Sector Refrigerator and will eventually support the operation of the Collider. This system is capable of providing 4000 watts of refrigeration at 0 g/s of liquefaction. During normal operations, the system will provide 2,200 watts of refrigeration and 22 g/s liquefaction. The maximum liquefaction rate is 40 g/s. The nominal mass flow of helium is 100 g/s with a minimum flow capability

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

expected to be near 20 g/s. The minimum operating temperature is 2.8 K. The operating pressure of the string is 4 bar. This system will be used at the ASST for the first time around June 1993 to cool down and operate the full cell being tested in Run 3.

The magnet power system consists of a high current DC power supply and an energy dump or extraction subsystem. The DC power supply capable of supplying a maximum of 8000 amps of current at up to 40 volts with a total output devaluation of ±100 ppm. This supply does not meet Collider requirements but is adequate for the ASST program. A small low conductivity water (LCW) supply system was assembled to provide cooling water for the power supply system. The energy extraction subsystem consisted of a dump resistor which could be placed in series with the magnets. The dump resistor has a maximum resistance of 40 mΩ with taps at 10, 20, 30, and 40 mΩ. These taps correspond to the nominal values required for a half-cell, full cell, one and a half cells and two full cells respectively. The resistance values are selectable in 2 mΩ steps. The dump switch consists of a SCR backed up by a mechanical switch. This switch is rated for currents in excess of 7500 amps.

The magnet power system is controlled by a local processor named the Collider Excitation Controller and Regulator (CECAR), and is monitored from the ASST Control Room. The operators can select the type of ramp, ramp rate and current value. The console display provides a schematic of the string under test and displays key electrical parameters in real time. These observables are stored in data buffers which can be read out and later stored in the ASST database.

The quench protection system (QPS) works in conjunction with the magnet power system. During Runs 1 and 2, the system had one quench protection module (QPM) which monitored quarter coil voltage taps on the string's magnets. This system is being expanded for Run 3 to include a second QPM to allow for tests that require QPM to QPM operations. Like the power system, the QPS is controlled and monitored in the control room. The console displays allow for the monitoring of the voltage taps and other diagnostic information. During a quench event, the voltages and currents which occur in the magnets and the bypass circuits are recorded in data buffers for later display and analysis. The magnet power and quench protection systems used at the ASST are discussed in reference [8].

The ASST has an integrated controls and data acquisition system which records data from the numerous sensors monitoring in the string components and the subsystems supporting the test operations. The Research Instrumentation Data Acquisition System (RIDAS) is the primary data acquisition system for test data. RIDAS is broken down into a VXI based data logging system and a VME based transient data recording system. To support the tests requested for the full cell configuration, RIDAS will log data from over 420 separate sensor channels. The periodic data logging has been performed at a sample rate of five minutes. The transient data system can accommodate up to 320 channels with its ten A/D modules. This system can accommodate a wide range of sampling rates and collection times. During the half-cell tests, sampling rates and collection times varied from 2000 samples per second for 30 seconds to 10 samples per second for 30 minutes. In addition to RIDAS, the controls system contains the cryogenic process controls system which monitors 80 sensor channels from the string and controls 25 remote devices. There is also a vacuum process controls system which has approximately 40 sensor channels.

III. COLLIDER MAGNETS TEST PROGRAM

The initial test (Run 1) was the milestone demonstration effort and was successful from that point of view. It was, however, not a test program for determining performance parameters for the half-cell configuration of magnets and spools. During Run 1, some test data was acquired on the thermal behavior of the string and the electrical response during ramping and quench, but only enough to verify that much more was needed to understand the behavior of the components. At the conclusion of Run 1, the string was warmed to room temperature so that equipment modifications and repairs could be made.

The repaired string was cooled down to cryogenic temperatures in October 1992, and the testing program resumed with Run 2. This program ran though January 1993 with a two week break in December when the cryo system was shut down and the string allowed to warm on its own. Over fifteen different test requests received testing time and where able to collect data.

Examples of the type of tests attempted include: measurements of the thermal performance of the magnets and SPR spool; the quench response of the half-cell at various current levels from quenches induced with either spot or quench protection heaters; the evaluation of the SPR bypass lead; the dipole down ramp sensitivity in the string; cold mass vibration monitoring; and superconducting splice joint measurements. Many of these tests and the results are discussed in references [5,6].

The first run of a full cell of ASST magnets will begin in June 1993. Using the results from Run 2, several magnets were changed in the first half-cell and the second half-cell installed. A specially instrumented dipole magnet (DCA323) was added to the first half-cell to measure where heat leaks occur in the dipole cryostat design. The string will include a new recooler spool (SPR) which is also heavily instrumented to provide data on its performance that could not be acquired before. The primary objectives of Run 3 are to acquire data on the thermal performance of the dipole magnets, the electrical response of the string components at 4.25 K, the performance of the SSCL designed SPR spool and finally, to test two vendor designed and manufactured SPR spools. The first part of this run is expected to last four to five months. At that point, the string will be warmed to room temperature and on of the vendor SPR's installed and tested. This will be repeated two months later for the second vendor spool. This part of the testing program will end in the spring of 1994.

The first three test runs of the ASST magnet string used or will use the ASST style magnets designed by the laboratory and fabricated at either Fermi National Accelerator Laboratory (FNAL) or at Brookhaven National Laboratory (BNL) by industry. The test data will be used by the laboratory's industrial partners (General Dynamics, Westinghouse and Babcock & Wilcox) during the development process of modifying the laboratory design for the dipole and quadrupole into the industrial design that will eventually be manufactured in large quantities and installed in the collider. Planning is in progress for a full cell string test using industry designed and built collider dipole and quadrupole magnets, and spools. This string test has not yet been officially approved by the laboratory management. These magnets will most likely be preproduction units as opposed to prototypes. Assuming that the Collider installation contract is awarded in June 1994, this test could then to take place in the first half of FY95. The primary objectives of this string test would be to verify the mechanical design and stability, the thermal and electrical responses under varied ramping and quench conditions and the vacuum performance during cool down for the string. Secondary objectives would be to test the magnet installation techniques and to provide experience to the installation contractor's personnel prior to any installation effort in the actual collider tunnel.

The Early Cryo Loop (ECL) test is another M1 level milestone for the SSCL. The results of M1 milestones are reported back to the DOE and Congress. The ECL test string will be installed in the Collider tunnel. This string will consist of four cells of Collider magnets and spools installed at the N15 Arc Sector Refrigerator feed point and proceeding northward. The four cells will be split between the upper and lower Collider rings. In addition to the dipole and quadrupole magnets, this string will contain two empty cryostats (EC) which provide cold drift space in the lattice. Although the planning for this test is still in the early stages, the basic test objectives are the same as in earlier tests. Those are to verify the operation of the components, subsystems and systems required to operate the Collider accelerator. The ECL test will be the first opportunity to test the ability of the Arc Sector Refrigerator to deliver cyrogens to magnets a couple hundred feet underground in a controlled manner to cool down and operate a part of the Collider lattice.

IV. SUMMARY

The ASST is an operating test facility for superconducting magnet strings at the SSCL. Two test runs have been completed using prototype magnets in a half-cell configuration. The test group has a comprehensive and aggressive test program planned for approximately the next three years using a full cell configuration of collider prototype and preproduction magnets. This program is based on the requirements and priorities established by the Collider Machine Group with input from the technical divisions. The results from this program will be fed back into the engineering effort for the superconducting components in the accelerator lattice to improve their operational performance and lifetime. The basic Collider test program will culminate with the Early Cryo Loop Test, which is another M1 milestone for the SSCL. At this point, the HEB Machine Group will be utilizing the ASST surface facility to conduct a HEB magnet string testing program.

V. ACKNOWLEDGMENTS

The authors would like to express their appreciation to the many individuals have contributed to this facility's success. In particular, we would like to recognize the contribution made by J. Grossholz during the construction phase and the continuing contribution by the crews of support personnel working under L. Cromer (CAD and engineering support), H. Carter (cryo operations), C. White (mechanical installation) and M. Hentges (testing and operations).

VI. REFERENCES

[1] W. Burgett et al., "Full-Power Test of a String of Magnets Comprising a Half-Cell of the Superconducting Super Collider," SSCL-Preprint-162 (1992), to be published in Particle Accelerators.

[2] Project Management Plan for the Superconducting Super Collider, SSCL Document No. P40-000021.

[3] Element Specification-Collider Accelerator Arc Sections, SSCL Document No. E10-000103.

[4] P. Kraushaar, "The Accelerator Systems String Test Program," Proceedings of the Fifth Annual International Industrial Symposium on the Super Collider, 1993.

[5] W. Robinson et al., "Electrical Performance Characteristics of the SSC Accelerator Systems String Test," these proceedings.

[6] A. McInturff et al., "Collider Scenario Implications of ASST Operation," these proceedings.

[7] G. T. Mulholland, "The ASST Cryogenics," Proceedings of the Fifth Annual International Industrial Symposium on the Super Collider, 1993.

[8] G. Tool, "Electrical Systems for the Accelerator Systems String Test," Proceedings of the Fifth Annual International Industrial Symposium on the Super Collider, 1993.