Fermilab

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Revised

Documentation of Fermilab SSC CDM R&D Activities for FY 1992

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This report covers the SSC collider dipole magnet R&D work done at Fermilab during fiscal year 1992 and the first quarter of fiscal year 1993. Since this is the program that was originally intended to be executed entirely during FY92, for the sake of this discussion it will be referred to as the FY92 R&D program.

The fiscal year 1992 Fermilab SSC magnet R&D program consisted of the following elements:

1) The evaluation of alternate conductor insulation systems which eliminate the glass tape but maintain a low cure temperature (<150 C). This work included cable pair, 10 stack, and test coil studies and short magnet and long magnet assembly and testing. The evaluation consisted of the the comparison of coil and 10-stack properties, cable pair insulation breakdown test results, and magnet performance (quench, mechanical, magnetic field) among the different insulation systems.
2) The evaluation of alternate coil end part materials and manufacturing methods. This work involved the construction of test coils; several alternate material end parts were included in short model magnets.
3) The next iteration of "developable surface" coil end parts. This work involved the winding, curing, and sectioning of test coils.
4) Studies of the accuracy with which conductors are placed by the manufacturing process at the locations specified by the design and the manufacturing parameters that affect this placement. This was planned to consist of the precise optical measurements of strand positions in highly polished cross-sections cut from most of the short magnets built and tested during late FY91 and FY92. Considerable effort was expended during the first quarter of FY92 specifying and selecting an optical measuring and analysis system that would perform these measurements. It was then decided by the SSCL that no funds should be spent to purchase such a system if it were to be stationed at Fermilab. We forwarded the specifications and lists of potential vendors to the SSCL and did not pursue the cross-section measurement further. However, two magnets from the FY91 series and 3 collared coils which were assembled as part of the insulation development project were sectioned and polished during FY92.
5) General R&D. This included various tests and data analyses in support of the ASST magnet program and and was directed at various problems and questions which arose in the course of other magnet work. Examples of this include tests and studies done

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early in the fiscal year on tooling and assembly parameters, analyses of data from ASST magnets and corresponding short models, the rebuilding of two short dipoles, one to try to understand the cause of anomalous quenching on the down ramp and the other to verify the understanding of the cause of several low initial training quenches in long ASST magnets. This also included the analysis of data from all magnet tests that occurred during FY92.

The most important results of the Fermilab SSC magnet R&D program have been documented in a series of papers presented at several international conferences. These papers are listed below and attached (Attachment 1) to this report.

Presented at the Fourth International Industrial Symposium on the Super Collider, New Orleans, Louisiana, March 4-6, 1992.

J. Strait, et al., Quench Performance of Fermilab/General Dynamics Built Full Length SSC Collider Dipole Magnets.

M. Wake, et al., Mechanical Behavior of Fermilab/General Dynamics Built 15m SSC Collider Dipoles.

S. Delchamps, et al., Magnetic Field Measurements of Fermilab/General Dynamics Built Full Scale SSC Collider Dipole Magnets.

M.J. Lamm, et al., Results from the Fermilab 1.5 m Model Magnet Program

M.J. Blessing et al., Construction Experience with Fermilab-Built Full Length 50 mm SSC Dipoles.

D.L. Assel, et al., Overview of a Robotic System for Azimuthal Dimensions of SSC Dipole Coils.

W. Koska and R.E. Sims, A Design for a High Voltage Magnet Coil Ringer Test Set.

Presented at the Third European Particle Accelerator Conference, Berlin, Germany, March 24-28, 1992.

M. Wake, et al., Magnetic Field Properties of SSC Model Dipole Magnets.

Presented at the ICFA Workshop on AC Superconductivity, KEK, Tsukuba, Japan, June 23-25, 1992.

S. Delchamps, et al., AC Loss Measurement of SSC Dipole Magnets.

Presented at the XVth International Conference on High Energy Accelerators, Hamburg, Germany, July 20-24, 1992.

J. Strait, et al., Magnetic Field Measurements of Full Length 50 mm Aperture SSC Dipole Magnets at Fermilab.

M. Kuchnir, et al., SSC Collider Dipole Magnets Field Angle Data.

J. Kuzminski, et al., Quench Performance of 50-mm Aperture, 15-m-Long SSC Dipole Magnets Built at Fermilab.

Presented at the 1992 Applied Superconductivity Conference, Chicago, Illinois, August 23-28, 1992.

T.S. Jaffery, et al., Test Results of Post-ASST Design Fermilab Built 1.5 Meter, SSC Collider Dipole Magnets.

J.P. Ozelis, et al., AC Loss Measurements of Model and Full Size 50 mm SSC Collider Dipole Magnets at Fermilab.

M. Kuchnir, et al., Magnetic Field Angle Changes During Manufacturing and Testing of SSC Collider Dipoles.

M.J. Lamm, et al., A facility to Test Short Superconducting Accelerator Magnets at Fermilab.

Essentially all of the work done during FY92 (and previous years) is documented in a series of internal technical notes, the "TS-SSC" series. A complete set of these notes generated during 1990 - 1992 have been forwarded to the SSCL Document Control Department. An index of these notes is attached (Attachment 2) to this report. The most important of these reports are also attached. They are grouped by topic and are listed here.

Data Summaries (Attachment 3)

J. Strait, et al., Summary of ASST Magnet Test Data, TS-SSC 92-072, 6/5/92.

J. Strait, et al., Review of Fermilab Short Model Dipole Test Results, TS-SSC 92-087, 10/27/92.

R. Bossert, SSC Short Models Built at Fermilab, TS-SSC 92-088, 12/17/92.

Mechanical Measurements and Assembly Tests (Attachment 4)

J. Strait, DCA 311 and DCA312 Return End Coil Spring Rate, TS-SSC 91-194, 10/7/91.

J. Strait, Effect of Reduced Press Load on Shell Tension, TS-SSC 91-196, 10/9/91.

J. Strait, DCA311 End Loads from End Bell Welding, TS-SSC 91-198, 10/15/91.

W.A. Higinbotham, Experiences of Welding the End Bell Assembly to the End Plate, TS-SSC 91-208, 10/28/91.

W. Koska, DCA311 Assembly Summary, TS-SSC 91-212, 10/29/91.

W. Koska, Measurement of End Plate Warp on DCA310, TS-SSC 91-215, 11/7/91.

R. Arnold and M. Gordon, Cold Mass Diametral Variation Study, TS-SSC 91-222, 10/15/91.

M. Wake, Pressure-Size Diagram Update with DCA Series Long Magnet Data, TS-SSC 91-254, 12/26/91.

W. Koska, SSC Collider Dipole Magnet End Force Issues, TS-SSC 92-022, 1/21/92.

J. Brandt, Sectioning and Anaylsis of Iteration #2 Coil End Parts, TS-SSC 92-085, 11/20/92.

R. Bossert, Long Coil Springback Data, TS-SSC 93-002, 1/8/93.

Insulation System Development (Attachment 5)

R.E. Sims, Sizes and Moduli of First All-Kapton Coils, TS-SSC 91-211, 11/1/91.

R.E. Sims, Short Term Stress Relaxation of All Kapton, Wrapped 50 mm Inner SSC Cable, TS-SSC 91-213, 11/6/91.

J. Strait and R.E. Sims, General Plan and Rough Schedule for Conductor Insulation Tests, TS-SSC 91-217, 11/8/92.

R.E. Sims, Detailed 10-Stack Experiment Plan (Revision 1), TS-SSC 91-236, 11/18/91.

R.E. Sims, Detailed 10-Stack Experiment Plan (Revision 2), TS-SSC 91-139, 12/05/91.

M. Wake, Estimation from Ten Stack Measurement Results, TS-SSC 91-242, 12/13/91.

M. Wake, Estimation from Ten Stack Measurement Results (II), TS-SSC 92-003, 1/6/92.

R.E. Sims, Kapton-Epoxy Insulation and Apical-Cryorad System Tests, TS-SSC 92-018, 2/4/92.

J. Strait, Proposed Insulation Systems for Remaining Short and Long SSC Dipoles, TS-SSC 92-019, 2/5/92.

R.E. Sims, 10-Stack Studies of Polyimide-Epoxy Insulation Systems, TS-SSC 92-033, 2/12/92

J. Strait, Plan for Cable-Pair Insulation Breakdown Tests, TS-SSC 92-041, 3/20/92.

J. Strait, Additional Cable-Pair Insulation Breakdown Tests, TS-SSC 92-045, 3/31/92.

M. Wake, Coils for All Kapton Magnets, TS-SSC 92-062, 5/22/92.

J. Strait, Cable-Pair Insulation Breakdown Test Results, TS-SSC 92-065, 5/26/92.

R. Bossert, Cable Insulation for SSC 50 mm Magnets 1992, TS-SSC 92-066, 4/13/92.

Alternate End Part Material Development (Attachment 6)

R. Bossert, Alternate End Part Materials in FY92 Short Models, TS-SSC 92-083, 10/6/92.

A. Lipski, Alternate End Part Materials, TS-SSC 92-084, 2/12/92.

Short Magnet Test Summaries (Attachment 7)

J. Strait, DSA326 Quench Summary, TS-SSC 91-199, 10/25/91.

T. Jaffery, Test Results of DSA326 and DSA101, TS-SSC 91-216, 10/29/91.

T. Jaffery, Summary of DSA326 Quenches, TS-SSC 91-257, 10/91.

T. Jaffery, Test Results of DSA328, TS-SSC 92-026, 2/25/92.

T. Jaffery, Test Results of DSA329, TS-SSC 92-052, 4/7/92.

M. Wake, DSA323 Reassembly Plan, TS-SSC 92-086, 5/27/92.

T. Jaffery, Test Results of Fermilab 50 mm Aperture, Post-ASST Design Model Magnets, TS-SSC 92-076, 6/30/92.

T. Jaffery, DSA323B Quench History, TS-SSC 92-079, 7/25/92.

Long Magnet Strain Gauge and Quench Data (Attachment 8)

J. Strait, DCA311 Cooldown Coil Stress Change, TS-SSC 91-220, 11/12/91.

J. Strait, Shell Axial Stress Change with Excitation in DCA311 and DCA312, TS-SSC 91-240, 12/9/91.

J. Strait, Shell Azimuthal Stress Change with Excitation in DCA312, TS-SSC 91-243, 12/11/91.

J. Strait, DCA312 Quench Current versus Temperature, TS-SSC 21-250, 12/18/91.

J. Strait, DCA313 Shell Strain Gauge Data with Excitation, TS-SSC 92-010, 1/20/92.

J. Strait, Location of Low Current Quenches in DCA313 and DCA314, TS-SSC 92-016, 1/30/92.

M. Wake, DCA313-316 Axial Strain Change, TS-SSC 92-023, 2/22/92.

J. Strait, Location of First Quench in DCA317, TS-SSC 92-048, 4/6/92.

Magnetic Field Measurements (Attachment 9)

M. Kuchnir, Observation on DCA312 Field Angle Measurements, TS-SSC 91-224, 11/13/91.

M. Wake, ESR Field Meter Measurement of SSC Magnets, TS-SSC 92-002, 1/6/92.

M. Kuchnir, DCA311 Field Angle Change due to Cold Testing, TS-SSC 92-005, 1/9/92.

J. Strait, DCA311-319 a1 and a2: Predictions from Coil Size Measurements Compared with Measured Values, TS-SSC 92-064, 5/26/92.

J. Strait, Warm-Cold Harmonics Comparison in ASST Magnets, TS-SSC 92-073, 6/12/92.

S. Delchamps, Harmonics of Magnets with all Kapton and Apical Insulation, TS-SSC 92-069, 6/18/92.

AC Loss Measurements (Attachment 10)

J. Ozelis, Status of AC Loss Measurements of 1.5 m SSC Model Dipole Magnets at Fermilab, TS-SSC 91-205, 10/23/91.

J. Ozelis, Measurements of AC Losses in Long 50 mm SSC Collider Dipole Magnets at Fermilab, TS-SSC 91-249, 12/18/91.

J. Ozelis, Correction to AC Loss Measurements in Long SSC Collider Dipoles due to Observed DC Energy Dissipation, TS-SSC 92-001, 1/3/92.

J. Ozelis, Summary of AC Loss Measurement Results for Long Magnets at Fermilab, TS-SSC 92-061, 5/14/92.

Quench Protection Heater Tests (Attachment 11)

T. Jaffery, DSA328 Quench Protection Heater Test Results I, TS-SSC 92-025, 2/14/92.

T. Jaffery, DSA328 Quench Protection Heater Test Results II, TS-SSC 92-032, 3/3/92.

T. Jaffery, DSA332 Quench Heater Test Results, TS-SSC 92-080, 7/16/92.

Electromagnetic Calculations (Attachment 12)

M. Wake, Coil Deformation and Transfer Function Change, TS-SSC 91-197, 10/15/91.

J. Strait, Long 50 mm Magnet Inductance, TS-SSC 91-221, 11/11/91.

E. Schmitz, Electrical Modeling of Magnets - Upper Inner Section, TS-SSC 91-231, 11/27/91.

E. Schmitz, Electrical Modeling of Magnets - Long Time-Scale, TS-SSC 91-247, 12/12/91.

E. Schmitz, Analysis of Probe Effect in Magnet Ringing Waveform, TS-SSC 91-248, 12/12/91.

E. Schmitz, Analysis of Probe Effect in Magnet Ringing Waveform, TS-SSC 91-251, 12/18/91.

A. Mokhtarani, Effect of Reducing Cable Insulation on Harmonic Coefficients in 50 mm SSC Magnets, TS-SSC 92-028, 2/24/92.

M. Wake, Direct Calculation of Magnetic Field from the Measured Strand Positions, TS-SSC 92-056, 5/5/92.

M. Wake, Pressure Distribution Effect on Harmonic Components, TS-SSC 92-070, 6/1/92.

Date	Note Number	Title	Author(s)
92/03/23	TS-SSC 92-043	DCA321/POSITION OF COLLAR GAGE PACKS	KOSKA
92/03/23	TS-SSC 92-044	DCA320 TURN-TO-TURN SHORT LOCATED	STRAIT
92/03/31	TS-SSC 92-045	ADDITIONAL CABLE-PAIR INSUL. BREAKDOWN TESTS	STRAIT
92/03/31	TS-SSC 92-046	DCA319 PRODUCTION SUMMARY	KOSKA
92/04/03	TS-SSC 92-047	DCA321 COLLARED COIL HARMONICS	DELCHAMPS
92/04/06	TS-SSC 92-048	DCA317 LOCATION OF FIRST QUENCH	STRAIT
92/04/04	TS-SSC 92-049	YOKE DENSITY	STRAIT
92/06/16	TS-SSC 92-050	DCA321/INSTALLATION/SPOT HEATER VOLTAGE TAPS	TASSOTTO
92/04/16	TS-SSC 92-051	DCA317 PRODUCTION REPORT	DELCHAMPS
92/04/07	TS-SSC 92-052	RESULTS/FERMI 50MM DIPOLES(APRIL MSIM)	JAFFERY
92/04/24	TS-SSC 92-053	DCA322 POLE SHIM	KOSKA
92/04/24	TS-SSC 92-054	DCA322/POSITION OF COLLAR GAGE PACKS	KOSKA
92/04/27	TS-SSC 92-055	DSA332 POLE SHIMS	DELCHAMPS, WAKE
92/05/05	TS-SSC 92-056	CALCULATION/MAG. FIELD FROM STRAND POSITIONS	WAKE
92/04/04	TS-SSC 92-057	DCA322/ACTUAL GAUGE PACK POSITIONS	KOSKA
92/07/22	TS-SSC 92-058	UNUSED NUMBER	
92/06/26	TS-SSC 92-059	DCA318 PRODUCTION REPORT	GOURLAY
92/05/22	TS-SSC 92-060	COILS FOR ALL KAPTON MAGNETS	WAKE
92/05/18	TS-SSC 92-060B	50MM SHORT COILS UPDATE	WAKE
92/05/14	TS-SSC 92-061	SUMMARY/AC LOSS MEASURE./LONG MAGS. AT FERMI	OZELIS
92/11/18	TS-SSC 92-062	UNUSED NUMBER	
92/05/21	TS-SSC 92-063	DSA333 SHIM SIZE	WAKE
92/05/26	TS-SSC 92-064	DCA311-319/COIL SIZE MEASUREMENT PREDICTIONS	STRAIT
92/05/26	TS-SSC 92-065	CABLE-PAIR INSULATION BREAKDOWN TEST RESULTS	STRAIT
92/04/13	TS-SSC 92-066	CABLE INSULATION FOR SSC 50MM MAGNETS 1992	BOSSERT
92/07/22	TS-SSC 92-067	UNUSED NUMBER	
92/05/27	TS-SSC 92-068	DCA323 REASSEMBLY PLAN	WAKE
92/06/18	TS-SSC 92-069	HARMONICS/MAGS. W/ALL KAPTON & APICAL INSUL.	DELCHAMPS
92/06/01	TS-SSC 92-070	PRESSURE DIST. EFFECT ON HARMONIC COMPONENTS	WAKE
92/06/02	TS-SSC 92-071	DCA323/SIZE OF POLE SHIM	WAKE
92/06/05	TS-SSC 92-072	SUMMARY OF ASST MAGNET TEST DATA	STRAIT
92/06/12	TS-SSC 92-073	WARM-COLD HARMONICS COMPARISON IN ASST MAGS.	STRAIT
92/06/16	TS-SSC 92-074	DCA322 & 323/LOCATION CHANGE OF VOLTAGE TAP	TASSOTTO
92/07/10	TS-SSC 92-075	DCA321 PRODUCTION REPORT	WAKE
92/06/30	TS-SSC 92-076	TEST RESULTS/POST ASST DESIGN MODEL DIPOLE	JAFFERY
92/07/30	TS-SSC 92-077	DSA334 POLE SHIMS	STRAIT
92/06/03	TS-SSC 92-078	DCA323/POSITION OF COLLAR GAGE PACKS	KOSKA
92/07/25	TS-SSC 92-079	DSA323B QUENCH HISTORY	JAFFERY
92/07/16	TS-SSC 92-080	DSA332 QUENCH HEATER TEST RESULTS	JAFFERY
92/09/15	TS-SSC 92-081	DCA322 PRODUCTION REPORT	DELCHAMPS
92/09/24	TS-SSC 92-082	DCA320 PRODUCTION SUMMARY	KOSKA
92/10/06	TS-SSC 92-083	ALTERNATE END PLATE MATERIALS-FY92 SHORT MAG.	BOSSERT
92/02/12	TS-SSC 92-084	ALTERNATE END PART MATERIALS	LIPSKI
92/11/18	TS-SSC 92-085	SECTIONING&ANALYSIS OF ITER. 2 COIL END PARTS	BRANDT
92/11/18	TS-SSC 92-086	NOTE IN PROGRESS	GOURLAY
92/10/27	TS-SSC 92-087	REVIEW/FERMI SHORT DIPOLE TEST RESULTS	STRAIT, ET AL.
92/12/17	TS-SSC 92-088	SSC SHORT MODELS BUILT AT FERMILAB	BOSSERT
93/01/06	TS-SSC 93-001	DOCUMENTATION / R&D ACTIVITIES FOR FY 1992	STRAIT
93/01/08	TS-SSC 93-002	LONG COIL SPRINGBACK DATA	BOSSERT