Fermilab

TS-SSC 90-098
11 December, 1990

MEMO TO: P. Mazur and E. Willen

FROM: J. Strait and J. Tompkins

SUBJECT: Wiring List for Single Magnet Tests

The number of instrumentation and heater wires exiting the magnet at each end for single magnet tests, along with the number for the string test, must be defined to allow design work to proceed on test facility modifications at FNAL and BNL and on the magnet instrument bus. Attached is a list specifying the number and type of wires leaving each end of the magnet for each type of instrumentation. It is based on a memo from John Tompkins to Helen Edwards dated 11/14/90 in response to the Technical Directors Office action item 90-0005 and on the specification of magnet test instrumentation prepared for the data package for Collider Dipole Magnet In Process Design Review 12/19-20/90. Both are attached. They assume 1) 59 coil voltage taps, 2) six taps on the bus, 3) two collar gage packs, 4) "bullets" at one end, 5) two resistance thermometers at each end, 6) shell strain gages at seven locations, 7) two spot heaters, and 8) four strip heaters. We have added to this list by allowing for up to 8 strip heaters (see note [2] on the wiring list) and adding voltage taps across each strip heater and two pressure transducers. The latter are installed principally for the string test but will probably be connected during single magnet tests. We have also added a complement of high and low voltage wire for contingency and special tests.

To avoid confusion about which end of the magnet is which, the ends have been labeled in three ways: 1) lead vs. non-lead end of the collared coil, 2) the end with or without the expansion loop, and 3) the end connected to the feed can or the turnaround box. The third applies to the scheme to be adopted at FNAL and may or may not apply at BNL.

This list is intended as a specification for the wires leaving the magnet, not for the wires used in the test stand or for bussing signals out from magnets within the string. Different gauges or voltage ratings may be desirable in the latter applications but this is not addressed here. This is also, of course, a working document and any comments or suggestions you may have can be incorporated in later versions.

cc (w/o attachments):
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50 mm SSC Dipole
Single Magnet Test Wiring List

Device	Wire Type		Turnaround Box w/o Exp. Joint Lead	Feed Can w/ Exp. Joint Non-Lead	Cryostat
1/4 Coil Taps (5)	#22	1 kV	5		
Multi V Taps (59)	#32	1 kV	35[1]	24	
Bus V Taps	#32	1 kV	2	4	
Collar Gages (28x4)	#32	30 V	56	56	
"Bullet" Gages (10x4)	#32	30 V	40		
Thermometers (4x4)	#32	30 V	8	8	
Shell Gages (18x4)	#32	30 V			72
Spot Heaters (2x2)	#22	400 V	2	2	
Prot. Heaters (8x2)	#18	1 kV		16[2]	
Prot. Htr. V Taps	#32	1 kV		16[2]	
Pressure Transducers	#32	30 V	4	4	
Contingencies:					
V Taps	#32	1 kV	12	12	
Strain Gage, etc.	#32	30 V	24	24	
Spot Heaters	#22	400 V	2	2	

Notes:

[1] Includes five 1/4 coil taps

[2] Actual number of leads required depends on final heater design which is not currently available. The current design due to Chris Haddock calls for two heater strips per quadrant which would be wired in pairs either in series of in parallel. However, until the final heater design and wiring scheme is settled it seems prudent to allow to wire each end of each heater strip out of the test stand. The heater strips each have one terminal at each end of the magnet. Heater power and voltage tap wires from the lead end of the magnet must be bussed to the non-lead end through the instrumentation bus.

SSC MAGNET SYSTEMS DIVISION
Test and Data Management Group

November 14, 1990

MEMORANDUM

To: H. Edwards

From: J. Tompkins

Subject: Action Item 90-0005 SDT/ASST Dipole Magnets - Single Magnet Test Instrumentation

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The instrumentation needed for a single magnet test is based on the present instrumentation package used in the 40mm magnets. It is needed to understand the quench and mechanical performance characteristics of the development magnets. A more detail discussion is attached as Appendix I. In the SDT/ASST the only instrumentation leads that are to exit the cold mass, which are used in the single magnet test as well as the ASST, are the spot heaters and quench heaters (number and which magnets are TBD) which will be in the instrumentation bus and one (or more) of the quarter coil voltage taps to be used in the quench detection scheme. Details of these connections are to be determined by ASST requirements (T. Dombeck/G. Tool). The bulk of the instrumentation will not be used in the SDT/ASST effort and will not exit the single phase region; the wiring will be tied off. The following is a preliminary list of the single magnet test instrumentation: the final instrumentation complement will be agreed upon by cognizant Magnet Systems Division personnel and members of the FNAL design team.

<u>Draft Single Magnet Test Instrumentation for 50mm Prototype Dipoles</u>

Voltage taps:	~60 coil taps[1] (quarter coils, fully instrumented first 6 turns from pole on inner coils, 2 taps in each ramp splice region) and probably 6 taps isolating the expansion joints for a total of about 66 voltage taps
Collar Gauge Packs:	2 fully instrumented packs[2] at the high and low points in the coil azimuthal size
End gauges	4 'bullet' assemblies[3] at the return end
Thermometry:	2 sensors at each end mounted as near to the coil as possible[4]
Shell gauges:	7 gauge assemblies (active and compensating); one at magnet center; six spaced appropriately over a 2m length from one of the cold mass ends[5]
Spot heaters:	2 located on the lower inner coil midplane; one near the end of the straight section at each end of the coil

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Quench heaters: 4 mounted against the outer coils in each of the four quadrants: they are *not considered test instrumentation* but they must exit the single phase region (presumably in the instrumentation bus).

Notes:

[1]Provision should be made to allow enough space for at least 10-12 additional voltage tap wires for special studies should they be warranted. Roughly half of the tap wires exit from each end of the magnet in the single magnet test.

[2]A collar gauge pack includes 4 active inner gauges, 4 active outer gauges, and 6 compensating (2 inner, 4 outer) gauges; each is a 4-wire measurement.

[3]A 'bullet' gauge includes two strain gauges; there are 2 compensating gauges mounted on the end plate for use with the 4 bullet gauges.

[4]In addition to the normal complement of temperature sensors mounted on the test stand; these are dependent upon availability. In single magnet tests, temperature sensors, pressure transducers, flow meters, etc. are integral to the test stand not the magnet (typically mounted in the interconnect regions on the stand end cans.)

[5]Shell gauges are mounted on the outer surface of the stainless steel skin forming the single phase region and are not part of the instrumentation that has to be dealt with the single phase part of the interconnects.

Appendix I

Background:

The 40mm dipole magnet test program has evolved a standard instrumentation complement which, based on the maturity of the magnet design, provides us with the data necessary to evaluate and understand quench and mechanical performance. In particular, the voltage tap arrangement has been reduced in scope to cover the first four turns from the pole since the quench origins are predominantly on the first turn for short sample quenches. However, this arrangement does not allow detailed study of quench propagation nor does it provide us with information on the origin of higher ramp rate quenches (some where in the turns between the midplane and the last instrumented turn as observed in the recent tests of magnet DD0028).

The strain gauge assemblies which measure the stress at the coil - collar pole interface, the so called 'gauge collar packs', are typically located at the low and high points in the inner coil azimuthal size along the length of the magnet. The strain gauge system provides details of stress history - including collaring , shell welding, creep, and cool down loss - as well as monitoring the stress change during magnet excitation. The strain gauge assemblies mounted on the end plates (called 'bullets') which press against the coil ends provide us with a similar history of the force between the coil end and the end plate during the magnet lifetime. Both of these systems are invaluable in understanding the mechanical behavior of the magnets and the data are compared to detailed FEA models of the collar-coil interaction.

The strain gauges mounted on the outer stainless steel 'skin' which encloses the single phase region are mounted after the skin has been welded. These gauges monitor changes in the stress state of the skin and provide data on the interaction between the skin and the iron yokes and, indirectly, the collared coil - yoke interaction.

Temperature measurements on the test stands are made in the interconnect regions and are complicated by heat leaks (e.g., power leads, instrumentation wires, bore tube, etc.). To better determine the temperature at the coil, we have been mounting two small carbon-glass thermometers in the bypass holes at both ends of the magnet; this was the closest practical mounting place.

Finally, spot heaters have been mounted at many places in the coils for specific studies: pole turn spot heaters to study quench propagation by inducing quenches at known positions and currents; midplane turn spot heaters to induce quenches for MIITs studies as well as 'calibration' points for pressure transducer measurements of axial quench location when the quench does not originate in an instrumented turn (e.g., outer coils); coil end spot heaters to study worst case (low field) quench development and MIITs. The standard spot heaters are located at the midplane turn of the lower inner coil, one at each end of the magnet, inside the straight section.

The 50mm Program

The dipoles for the SDT/ASST efforts will be the first full length FNAL 50mm magnets produced and tested. In addition to the aperture change, there are several other features which are new to the FNAL design:

- coil ends - constant perimeter, grouped design
- coil end support - clamps
- inner-outer coil splice
- vertical yoke split and 'pro-ovalized' collared coil
- changes in ground insulation and removal of pole shims
- interconnect - end dome, small helium passages, new expansion joint

plus other subtle details. The impact of these changes in mechanical design on magnet performance must be understood. We have a fairly mature body of data on the 40mm BNL design and must rapidly accumulate similar information for the 50mm design since it is crucial to the design process which will be underway at our magnet vendors.

One of the outstanding issues of the 40mm program is the origin of the high quench velocities observed: the high velocities have a beneficial affect on quench development and limiting the peak temperature (MIITs). While models have been proposed ('thermo-hydraulic quench back' where the quench induced helium pressure wave heats the coil and thus helps propagates at the quench speed of sound in the helium) none fully explain the data. Thus measuring and understanding the quench phenomenon in the 50mm magnets is very important.

We are (with the FNAL staff) presently reviewing the instrumentation requirements for the full length 50mm dipoles. At this point in the process, we envision a package that is similar to that employed in the 40mm (BNL) long dipole program (I have attached a copy of Jim Strait's memo concerning instrumentation for the first FNAL 40mm dipoles and a detailed list of the instrumentation and wiring that is in use at present on the 40mm dipole test stands at FNAL. The only major differences between the BNL and FNAL lists are those due to the FNAL splicing scheme, and the observation - in test of short FNAL 40mm magnets - of quenches originating in turns not seen in the BNL magnets requiring a few additional voltage taps.)

In the 50mm magnet, the coils have more turns and slight changes in the wedge positions. The voltage tap scheme (under development) will necessarily incorporate some additional taps to isolate the first two wedges in the cross section. For purposes of estimating wiring requirements, we fully instrument the turns between the first two wedges, increasing the number of voltage taps by about 16. This results in a total of about 60 coil voltage taps, including the quarter coil taps and taps that isolate the inner-outer coil splices. Additional taps will also be necessary to monitor the new expansion joints for the superconducting leads. Since the interconnect region design is quite different from the 40mm magnets, these taps must also be accommodated in the instrumentation bundles exiting the single phase region.

We expect to come to an agreement with the FNAL magnet designers on a standard instrumentation package for the full length 50mm dipoles within two weeks. I believe that the final package will not deviate significantly from that outlined here. However, the first 50mm dipoles are very important elements of the overall magnet program and we must ensure that we maximize the information obtained from them. The instrumentation list presented represents a mature form of the package developed in the 40mm program. I have not included additional devices that might be called for on a 'per magnet' basis (such as extensometers, or additional strain gauges, spot heaters, or voltage taps for quench origin/propagation studies, etc.) that might be necessary to understand some aspect of magnet performance. All designs which impact the ability to install or connect instrumentation for single magnet tests should treat these lists as a baseline for R&D instrumentation and be able to accommodate reasonable increases in the number of high and low voltage sense wires should it be required by the development program.

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Fermilab

November 5, 1990

MEMO TO: R. Bossert, J. Carson, S. Delchamps, N. Hassan, W Koska, P. Mantsch, P. Mazur, D. Orris, G. Pewitt, R. Rihel, G. Tassotto, M. Wake, M. Winters, W. Zimmerman

FROM: Jim Strait

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SUBJECT: Revision to Instrumentation for 40 mm Long Magnets

Attached is a revised specification for the instrumentation on long 40 mm SSC dipoles built at FNAL. I have changed the specified locations of the skin gages to more closely match what has been put on BNL magnets tested here.

cc: T. Bush
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