SLAC Magnetic Measurement Plan and Traveler for the FACET Sextupole Magnet S2E#2 S202335T (style 1.625SX29.2)

Account Number to be charged: 9141204

This traveler covers the magnetic measurements plan for one of 2 identical water-cooled sextupoles, of engineering type 1.625SX29.2, called S2E#2, to be used as S202335T in sector 20 in FACET.
This sextupole was made in 1986 at SLAC and previously ran in the SLC FF here at SLAC. Consequently it may have a very little residual radioactivity, the levels are marked on radiation tags and Jim Allan (ext 4064) can provide you further information on the type of radiation and what precautions you should take when handling these magnets.
This magnet weighs about 560 lb, and comes to you on a special channel support which sits on its final T1 mount, the assembly weighs more than 560lb (=953lb). It has yellow labels that indicate its beamline position in FACET (S202335T). It will run on its own power supply (hurrah).

1. Receiving Information:

Received by (MM initials)	SDA
Date received : (dd-mm-yyyy):	9 - 30 -2010
Checked Magnet Number(S2E#2),Optics name(S202335T)	
Magnet Engineer (Cherrill Spencer or her substitute) verifies that this magnet is ready to be magnetically measured. The refurbishment is finished as much as it can be at this time.	CMSpencer 30th Sept 2010
If sextupole does not have a barcode sticker then ask Magnet Engineer to add one and she will write the 6 digit barcode number here:	002198

Retrieve past measurements (from July 1986, when this magnet was called 53SX07 or 1.625SX29.2#6. Attach copy of old record (from David Jensen):

53SX07, old measurements attached (check):	

Preparation:

2. Power and LCW Connections: Unipolar PS >=250A , 30 V required. Cosine-shaped ramp that mimics the ramps produced by an Ethernet-driven controller.
High pressure LCW system will be needed to cool this magnet in your measurement lab.

3. Magnet Orientation:
A beam direction arrow, should be visible on the top or side of the core, .Notice: This magnet has coil interconnects, power terminals and water fittings **downstream.** If there is no arrow, contact Cherrill Spencer, x3474.

Beam-direction arrow in place (initials):	SDA

4. Magnet Alignment:

This magnet has sockets for 4 old tooling balls (TBs), they were last fiducialized in 1986 and now it has several new TB sockets. Alignment crew should do a translation from old to new TBs (as Cherrill previously discussed with them), could be done before magnet arrives at MMG.

Fiducialization of new TBs complete (Alignment Initials :)	

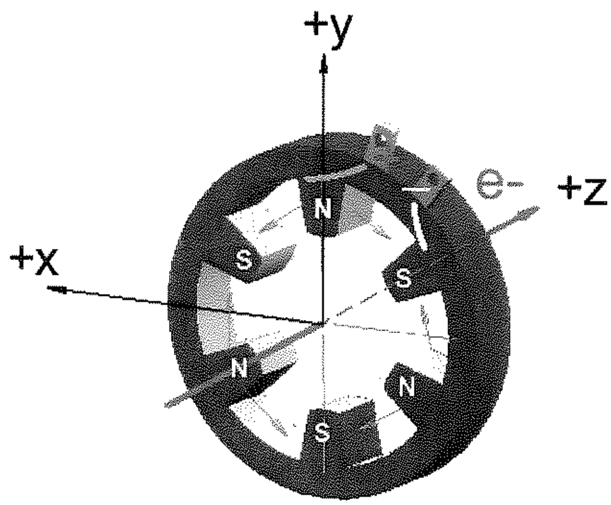
Alignment crew should do set up on measurement stand , and use the x,y,z axes of the whole magnet (as defined by TB measurements) such that the roll angle (angle of horizontal axis) is less than about 0.2 milliradian (or as small as possible), and pitch and yaw is also minimized.
Fiducialization data on location of tooling balls with respect to geometric axis when poles are aligned perfectly horizontally should be saved.

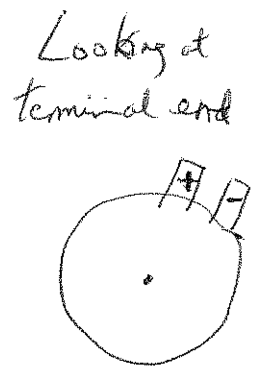
Alignment completed, Roll Angle = ________millirad (Alignment Initials :)	

The rotating coil should have its windings oriented that a 'zero' angle quoted for a pole is indeed zero relative to the horizontal axis defined by the alignment crew. (Angle of first south pole, and of higher multipoles is important). A stretched wire will be used before the rotating coil – see step 11.

5. Power leads and polarity:

The required polarity for S2E#2 is *defocussing for electrons on the positive x side of the center.*
This means the topmost pole must be a NORTH pole as shown in the figure below.
This cartoon shows the power terminals upstream, in fact they will be downstream, so ignore the terminals in this cartoon.





Determine the electrical connection polarity (with supply outputting positive current) which produces the required magnetic field polarities.
Place + and - labels on or near the main power flags for the required polarity.

Polarity established, power +/- labels applied	SDK

6. Cooling Water Flow Check:

Each sextupole has 3 water circuits, there are 2 coils in series in a water circuit. There are 2 LCW input spiggots and 3 output spiggots. I will attach the top assembly drawing AD-235-017-

00 so you can see which are LCW inputs and which outputs. There is no water manifold coming with the sextupole, please use your own manifold.
Adjust the differential pressure across each water circuit (deltaP) to be about 150 psi.
Total water flow should be about0.53 gpm. If you cannot adjust deltaP to 150 psi, first use 200 psi (or max), measure the flow, then make total flow0.53 +/-0.2 gpm by adjusting the valve).

	Water flow [gpm]	Check
Maximum delta P _______		
Adjusted to produce 2.6	2.6 or 0.688 gpm	

7. Thermocouple placement and Thermal Test: (thermal test to be done onS2E#2 only)
Place 5 thermocouples at these locations:
- any one of the coils – on the incoming LCW – on the outgoing LCW -elsewhere on bench for ambient temperature measurement – on the steel core near any pole tip.
Arrange for temperatures to be read at least once every 3 minutes for the following thermal test:
After water flow has been checked on each circuit, run JUST the FIRST sextupole to 140 A for three hours, reading the thermocouples, magnet current and voltage.

Confirm total LCW flow is 0.53 +/- 0.2 gpm	Flow is 0.69 gpm
Name of thermal test file and date of test	rtdat.ra1
URL of webpage where datafile stored	
Final LCW temp (in) – Final LCW temp (out)	= 19.0 °C

If the rise in the LCW temperature is more than 23 deg C, something is wrong; stop, call Cherrill Spencer at x3474 or substitute.

8. Initialization:

To be done only once, after successful completion of the water flow check and Thermal Test above. Use the cosine ramp with an equivalent linear rate of 15 A per second; minimum current of 5 A, maximum current of 175 A and pause time of 120 seconds at the minimum and maximum currents. Take the sextupole from 5 A to 175 A and back 7 times, ending up at 5 A

Initialization completed: date , MMG initials:	10 / 4 /2010 SDA

9. (a) Standardisation parameters and detail: (For use in measurements below)

Ramp type: cosine shape
Minimum standardisation current: 5 amps
Maximum standardisation current : 140 amps
Pause time at minimum or maximum standardization current: 30 seconds
Equivalent linear ramp rate for standardization process: 15 amps/second (increasing or decreasing)
Start at 5 A and ramp up to 140 A and down to 5 A three times, finishing at 5 amps. A standardization procedure always involves three up and down ramps; the up ramp followed by the down current ramp is called a *cycle.*

Setting to desired current (BDES) : ramp UP to BDES at 5 amps/second

All operating currents should be approached from below; except when I request a series of decreasing currents – these will be approached from a higher current. When moving from one current to another for the strength or harmonics measurements use 5 amps/second and wait at least 30 seconds after the operating current has been reached before making any magnetic measurements. Put basic standardization details in all datafile comments.

Confirm that magnet will ramp at 15 A/s (initials:)	SDA

9 (b) Multiple standardization cycles to be carried out BEFORE any measurements are made. NEW instruction for the remaining FACET magnets.

To avoid the situation where the integrated strength at a fixed current continues to vary when the magnet is powered off and then on again and measured after a single standardization procedure, I ask you to carry out many standardization cycles on this style sextupole before any measurements are made on it. This will "train" the magnet into a state to produce a repeatable integrated strength when it is powered up in the beamline. Take the sextupole through 51 standardization cycles (equivalent to 17 standardization procedures)

Sextupole has undergone 51 standardization cycles	Date: 10/5/2010 Start time: 9:38

10. Poletip Field Measurements

When it is convenient, maybe when the rotating coil is not in the sextupole's aperture, please use a Hall probe to measure the poletip field at 79 amps (after a regular standardization procedure) . Please make a correction in the field value for the thickness of the Hall probe.

Current Actual current 79.05	Poletip field : 0.338 T
79 A nominal	
Date and inititals:	10 / 5 /2010 SDA

11 (a) Stretched Wire Measurement to calibrate the rotating coil:

If a stretched wire is used to calibrate the rotating coil then record the datafile name and URL:

http://www-group.slac.stanford.edu/met/MagMeas/MAGDATA/FACET_Sector_20/ S2E#2 / DC 34 Coil Calibration /

11 (b) Stretched Wire Measurement to Estimate Harmonics- NEW instruction

Based on observations of the behavior of the rotating coil DC34qadd we need to make some stretched wire measurements to estimate the sizes of the multipoles, especially the 18-pole.
Set up a stretched wire along the x=0, y=0 magnetic center of the sextupole's aperture, have an Alignment Crew help set it up as well as they can.

Standardize and ramp up to 79 amps at 5 amps/second. Pause for 30 seconds before taking any data.

Measure integral B.dl at the following x positions (and y=0) with the stretched wire:
-1.8,-1.5,-1.2,-0.9,-0.6,-0.3, 0.0, 0.3, 0.6, 0.9, 1.2, 1.5, 1.8 cm
Go back across the aperture at the same x in reverse order and measure integral B.dl at 79 amps. Put all the data in the same data file.
Tell the Magnet Engineer when this data is available and don't remove the stretched wire until the Magnet Engineer says it's OK to proceed.

Filename of Wire-Harmonics Measurement	wireusx .ru 2
Date of measurement, initials	10/ 6 /2010

12. Rotating Coil Magnetic Measurements: ∫G'.dl and harmonics at various currents.
Purpose of these measurements is to find the transfer functions (Current required to reach a certain integrated gradient-primed strength) especially for the desired integrated gradient-primed, and to check that the multipole harmonics do not exceed FACET requirements.

For S2E#2, the desired ∫G'dl is -12861.298 kGauss/m (will need about 79 A)

Rotating Coil Designation (Name)	Dc 34
Rotating Coil Radius	0.009

13. Integrated Strength Measurements:
Measure the integrated gradient' ∫G'dl at these currents:
20, 40, 50, 60, 70, 79, 90, 100, 110, 120, 130, 140 amps
Then back to 20 amps from 140 amps, measure the ∫G'dl at the same set of currents in reverse order. Remember to ramp at 5 amps/second and wait for 30 seconds after reaching the new current before starting a measurement.

Filename of Int. Strength Measurement	Strdat .ru 4
Date of measurement, initials	10 / 13 /2010

14. Harmonics Measurements (with rotating coil, still do this, for comparison with stretched wire measurements in step 11(b)):
Measure the strength and angle of each multipole component at 79 amps.
(or at the operating current provided after analysis of integrated strength measurement).
Multipole values should be given as a percentage of the sextupole moment calculated at a 1cm radius even though the rotating coil's radius is under 1cm, PLEASE. Also provide the magnetic center X and Y coordinates measured during the harmonics measurements at the above current.

Filename of Harmonics Measurement	hardat .ru 4
Date of measurement, initials	10 / 13 /2010

15. Polarity Reversal Test: **THIS TEST WILL BE DONE ON S2E#2 to check the multiple standardizations in step 9(b) are sufficient to train this 1.625SX29.2 style sextupole.**

REVERSE THE POLARITY OF S2E#2 and redo the integrated strength and harmonics measurements (16, 17 below).
Swap the power cables on S2E#2 when you have done its nominal polarity data-taking and do one standardization procedure [3 cycles] in the new polarity and redo the measurements of integrated strength and harmonics, as indicated below *[when we have seen the stretched wire estimate of multipoles from step 9 (b) we will discuss whether the stretched wire needs to be used during the reversed polarity measurements or not].*
The magnet engineer will do a comparison of the polynomials in the two polarities and decide if the single standardization is sufficient to maintain the behavior of the sextupole.
Then swap back to the original polarity and standardize JUST ONCE and do the strength and harmonics measurements again (18,19 below) and the magnet engineer will do a comparison analysis and tell you of she needs any further measurements or if the same reversing polarity test has to be done on all 1.625SX29.2 sextupoles.

16. Reversed Polarity Integrated Strength Measurements:
Measure the integrated gradient' ∫G'dl at these currents:
20, 40, 50, 60, 70, 79, 90, 100, 110, 120, 130, 140 amps
Then back to 20 amps from 140 amps, measure the ∫G'dl at the same set of currents in reverse order. Remember to ramp at 5 amps/second and wait for 30 seconds after reaching the new current before starting a measurement.

Filename of Int. Strength Measurement	Strdat .ru5
Date of measurement, initials	10/14/2010

17. Reversed Polarity Harmonics Measurements:
Measure the strength and angle of each multipole component at 79 amps.
(or at operating current provided after analysis of integrated strength measurement).
Multipole values should be given as a percentage of the sextupole moment calculated at a 1cm radius. Also provide the magnetic center X and Y coordinates measured during the harmonics measurements at the above current.

Filename of Harmonics Measurement	hardat .ru5
Date of measurement, initials	10/14/2010

18. Original Polarity Integrated Strength Measurements:
Measure the integrated gradient', ∫G'dl at these currents:
20, 40, 50, 60, 70, 79, 90, 100, 110, 120, 130, 140 amps
Then back to 20 amps from 140 amps, measure the ∫G'dl at the same set of currents in reverse order. Remember to ramp at 5 amps/second and wait for 30 seconds after reaching the new current before starting a measurement.

Filename of Int. Strength Measurement	Strdat .ru6
Date of measurement, initials	10/14/2010

19. Original Polarity Harmonics Measurement:
Measure the strength and angle of each multipole component at79 amps.
(or at operating current provided after analysis of integrated strength measurement).
Multipole values should be given as a percentage of the sextupole moment calculated at a 1cm radius. Also provide the magnetic center X and Y coordinates measured during the harmonics measurements at the above current.

Filename of Harmonics Measurement	hardat .ru 6
Date of measurement, initials	10 / 14 /2010

The magnet engineer will do a comparison of the polynomials in the two polarities and decide if the single standardization procedure is sufficient to maintain the behavior of the sextupole. Check with her/him before removal of S2E#2 from bench.

Magnet Engineer Approval obtained	CMSpencer Oct / 20 /2010

20. Saving and Distributing the Magnetic measurement data

Please post all data at

http://www-group.slac.stanford.edu/met/MagMeas/MAGDATA/FACET_Sector_20/sextupole/
S2E#2

in a subdirectory with the magnet name.
Please inform Magnet Engineer (Cherrill Spencer at cherrill@slac.stanford.edu (ext 3474). and /or achim@SLAC.Stanford.EDU, wittmer@SLAC.Stanford.EDU of FACET) when the strength and harmonic measurement data are available for inspection and analysis, and for final approval .

21. This section is to be completed by FACET Magnet Engineer.

Data been inspected & analyzed by Magnet Engineer	CMSpencer 19 Jan 2011
Based on Magnet Engineer analysis of data can confirm the pre-assigned beamline location (optics-deck name):	Optics beamline location: S2E#2 S202335T
Sextupole is released from Magnetics Group, signed and dated by FACET Magnet Engineer:	CMSpencer 19 Jan 2011
Remove the LCW from the coils and take the magnet to the designated storage area. Signed & dated by MMG personnel:	Done in October 2010

22. This section is to be completed by FACET Beam Physicist (Walter Wittmer).

Checked that integrated strength data is satisfactory and have generated the polynomial function for the controlling database to set the magnet. Nominal operating current is 78.5 amps. Checked that this is within the capability of the assigned power supply max 87 A and	Signature and date: [signature] 01/20/11 max std = 140 A
Checked that the multipole values at r=10mm are below the Physics Requirements tolerances (initial):	[signature]
Magnet accepted for FACET (signed):	[signature]
Date accepted (Month-Day-Year):	01/20/11

When this traveler is completed, attach it to the refurbishment traveler of this magnet and send these hardcopies to the designated person in Kathleen Ratcliffe's group at MS 18 to be scanned into a pdf file. Then that electronic file will be stored in a place TBD and the hardcopies will be returned to sit with the magnet until it is installed in the beamline.

Two travelers for this magnet been scanned into a pdf file; by Catherine Creech	Name of pdf file Magnet S2E#2 S202335T
Two travelers been returned to sit with magnet in its "waiting for installation" place.	Signed & dated: [signature] 1-28-11

Further Tasks to be done on this magnet will be recorded on its Refurbishment Traveler.

END OF FACET S2E#2 (S202335T) MAGNET MAGNETIC MEASUREMENT PLAN AND TRAVELER