## **SLAC Magnetic Measurement Plan and Traveler for the FACET Sector 10 Quadrupole Magnet Q802T, Q100802T (Style 1.085Q4.31, "QE")**

## Account Number to be charged: 607301 REVISION #1 17Jan 2012

This traveler covers the magnetic measurements plan for a water-cooled quadrupole, of engineering type 1.085Q4.31, commonly known as a "QE" style quad, called Q802, to be used as Q100802T in sector 10 for FACET. It will run on its own power supply.

This magnet was made in 1984 by SLAC and previously ran, many years ago, in the main linac here at SLAC. It has no residual radioactivity. Its aperture diameter is 1.085" (27.56mm), its overall length is approximately 6.5". Its resistance is approx 0.082 ohms.

The magnet weighs about 140 lb., and it will come to you on its specially designed support. The total weight will be approximately 170 lb. It will have a yellow label that indicates its beamline position in FACET, Q100802T and Q802. Its top assembly drawing is SA-902-675-10 R3.

**1. Receiving Information:**

|  |  |
| --- | --- |
| Received by (MM initials) | SDA |
| Date received : (dd-mm-yyyy): | 19/1/2012 |
| Checked Magnet Number( Q802), Optics name(Q100802T) | X |
| Cherrill Spencer has inspected the refurbishment traveler and authorizes the MMG to do the magnetic measurements in this plan. |  |
| If quad does not have a barcode sticker then ask Magnet Engineer to add one and write the 6 digit barcode number here: |  |

**Preparation**

**2. Power and LCW Connections:** Unipolar PS >=200 A, 30 V required. The sector 10 magnets' power supplies run on PSC II controllers, so there will be an unusual ramping procedure- described in a section further on in this plan.

Regular 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): |  |

**4. Magnet Alignment:**

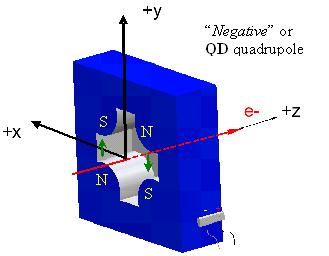
This magnet has a specially designed support [drawing SA-902-675-38] which all QE’s used in the main linac sit on; it has a way of being adjusted in height and our Alignment crew is familiar with how to set up a QE for use in the main linac. They should follow that procedure in aligning this quad on the measurement stand. *But on account of its position in the S10 beamline Alignment have decided to add to tooling balls to this Q802 and to fiducialize it using the newly added tooling balls.* They should set the roll angle (angle of horizontal axis) to be what we typically set QEs to. The pitch and yaw should also be minimized. The support will sit on a belly band around the linac light pipe.

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|  |  |
| --- | --- |
| Alignment completed, Roll Angle = 0 millirad (Alignment initials:) | LG, HI |

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. (Measuring the angle of first south pole of the quad, and of higher multipoles is important).

**5. Power leads and polarity:**

 The required polarity for Q802 is ***de****focussing for electrons.* Looking downstream, the upper-left pole should be a south pole as shown in this figure:

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 | SDA |

**6. Cooling Water Flow Check:**

This quadrupole has 4 water circuits, with 1 coil per water circuit, there are 2 input fittings and 3 output fittings that you will use to connect hoses to the temporary manifold you will provide.

Adjust the differential pressure across each water circuit (deltaP) to be about 80 psi.

Total water flow should be about 1.2 gpm. Please try to adjust the delta pressure to be 80 psi, measure the flow; then make total flow 1.2 gpm by adjusting the valve.

|  |  |  |
| --- | --- | --- |
|  | Water flow [gpm] | Check |
| Maximum deltaP 80 |  |  |
| Adjusted to produce 1.2 gpm: | 1.2 or | SDA |

**7. Thermocouple placement and Thermal Test:**

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 this quad at 165 A for three hours, reading the thermocouples, magnet current and voltage.

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| --- | --- |
| Confirm LCW flow is 1.2 +/- 0.1 gpm | Flow is 1.2 gpm |
| Name of thermal test file and date of test | RTDAT.RU1 |
| Final LCW temp (in) – Final LCW temp (out) | = 3.9 °C |

If the rise in the LCW temperature is more than 10 deg C, something is wrong; stop, call Cherrill Spencer at x3474 or substitute.

**8. Controlling the Power Supply and Initialization of the quad:**

**(a) Information on mimicking the PSCII power supply controller**

The standardization and setting of the current for the strength measurements is to be under the automatic command of the computer program which someone in MMG wrote over 10 years ago to mimic the PSCII controller running on the MMG PC. This quad will be cycled between 2 and 160 amps during its standardization process.

Here are the database entries needed in the VAX database to get the desired ramps, maximum currents etc:

DATABASE ENTRIES

|  |  |
| --- | --- |
| BMAX = | 160 |
| RAMP = | 4,5 |
| IMMS = | 2 ,160, 2 |
| IMMO = | 2, 160 |
| NSCY = | 5, 30000 |
| DVI = | 0, 218.45 |
| IVA= | 0, 30 |
| SETL= | 2000 |

The table below gives the LINEAR ramp rates you should use for the various parts of the standardization cycle. The *setting* ramp uses the *slow* ramp rate all the way and the SLC operating system forces a pause of several seconds (exact value depends on several other time values, the SETL value and which other magnets are being set at the same time) when the current reaches 95% of the *change* in current from the previous setting. The table below gives the pause I want you to provide.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Max. Std Current | fast ramp rate | slow ramp rate | Current where rate changes, fast to slow in Stand--ardization cycle | Extra pause in *setting* ramp at 95% of change from previous current. |
| 160 A | 17.6A/sec  PSC2 RAMP = 5 | 4.4 A/sec  PSC2 RAMP = 4 | 150.1 A on up  7.9 A on down | 5 seconds |

**(b) Initialization**

To be done only once, after successful completion of the water flow check above.

Use the above ramp method with an fast ramp rate of 17.6 A per second; minimum current of 2A, maximum current of 200 A and pause time of 120 seconds at the minimum and maximum currents. Take the quad from 2 A to 200 A and back 7 times, ending up at 2 A

|  |  |
| --- | --- |
| Initialization completed: date , MMG initials: | 1/20//2012 SDA |

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

Ramp type: PSCII style using a fast ramp rate and then a slow ramp rate during standardization

Minimum standardization current: 2 amps

Maximum standardization current: 160 amps

Pause time at minimum or maximum standardization current: 30 seconds

Use a fast ramp rate and a slow ramp rate for standardization process as described in table above.

*Start at 2 A and ramp up to* 160 A and down to 5 A FIVE times, finishing at 2 amps.

*Setting* to desired current (BDES): ramp UP to BDES at 4.4 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 4.4 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.

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| --- | --- |
| Confirm that magnet will ramp at 17.6 A/s (initials :) | SDA |

**10(a) Multiple standardization cycles to be carried out BEFORE any measurements done.**

Based on observations of the behavior of the other old SLAC quads when measured, it is necessary to carry out many standardization cycles on this style quad 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. The large number of cycles compensates for the low maximum standardization current. Take the quad through 25 standardization cycles (equivalent to 5 standardization procedures).

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| --- | --- |
| Quad has undergone 25 standardization cycles | Date: 1/20/2012 Start time: 4:20 |

**10 (b) Poletip Field Measurements**

When it is convenient, maybe when the rotating coil is not in the quad’s aperture, please use a Hall probe to measure the poletip field at 92 amps (after a regular standardization procedure) . Please make a correction in the field value for the thickness of the Hall probe.

|  |  |
| --- | --- |
| Nominal Current Actual current | Poletip field : |
| 92 A 92.03420 | 0.564 T |
| Date and initials: | 1/23/2012 SDA |

**11. Stretched Wire Measurement to calibrate the rotating coil:**

The aperture diameter is 1.085 inches. You will probably use coil dc34.

When you use a stretched wire to calibrate the rotating coil then record the datafile name &URL:

|  |
| --- |
| <http://www-group.slac.stanford.edu/met/MagMeas/MAGDATA/FACET_Sector_10/> |

**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 strength) especially for certain desired integrated gradients, and to check that the multipole harmonics do not exceed FACET requirements.

For the Q802 magnet the desired ∫G.dl is -51.1156 kGauss (estimate current will be ~92 A).

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| --- | --- |
| Rotating Coil Designation (Name) | DC34 |
| Rotating Coil Radius | 0.0090571 m |

**13. Integrated Strength Measurements:**

Measure the integrated gradient ∫G.dl at these currents:

20, 40, 60, 80, 90, 100, 110, 120, 130, 140, 160 amps

Then back to 20 amps from 160 amps, measure the ∫G.dl at the same set of currents in reverse order. Remember to ramp at 4.4 amps/second and wait for 30 seconds after reaching the new current before starting a measurement.

|  |  |
| --- | --- |
| Filename of Int. Strength Measurement | STRDAT.RU2 |
| Date of measurement, initials | 1/27/2012 SDA |

**14. Harmonics Measurements:**

Measure the strength and angle of each multipole component at 90 and 160 amps as the current is increased. Multipole values should be given as a percentage of the quadrupole component calculated at an 8mm radius. Also provide the magnetic center X and Y coordinates measured during the harmonics measurements at the above currents.

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| --- | --- |
| Filename of Harmonics Measurement | **HARDAT.RU3** |
| Date of measurement, initials | 1/27/2012 SDA |

**15. Saving and Distributing the Magnetic measurement data**

Please post all data at (fill in Magnet name)

|  |
| --- |
| <http://www-group.slac.stanford.edu/met/MagMeas/MAGDATA/FACET_Sector_10/>  QUAD/Q802T/ |

in a subdirectory with the magnet name.

Please inform Magnet Engineer (Cherrill Spencer at [cherrill@slac.stanford.edu](mailto:cherrill@slac.stanford.edu) (ext 3474). when the strength and harmonic measurement data are available for inspection and analysis, and for final approval.

**16.**  .**This section is to be completed by FACET Magnet Engineer.**

|  |  |
| --- | --- |
| Data been inspected & analyzed by Magnet Engineer |  |
| Based on Magnet Engineer analysis of data can confirm the pre-assigned beamline location (optics-deck name): | Optics beamline location: |
| Quadrupole is released from Magnetics Group, signed and dated by FACET Magnet Engineer: |  |
| Remove the LCW from the coils and take the magnet to the designated storage area. Signed & dated by MMG personnel: |  |

**22.** **This section is to be completed by FACET Beam Physicist (John Sheppard).**

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| --- | --- |
| 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 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_amps.  Checked that this is within the capability of the assigned power supply \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Signature and date: |
| Checked that the multipole values at r=8 mm are below the Physics Requirements tolerances (initial): |  |
| Magnet accepted for FACET (signed): |  |
| Date accepted (Month-Day-Year): |  |

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.

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| Two travelers for this magnet been scanned into a pdf file; by\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Name of pdf file \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| Two travelers been returned to sit with magnet in its “waiting for installation” place. | Signed & dated: |

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

END OF FACET S10 Q802 Q100802T MAGNETIC MEASUREMENT PLAN AND TRAVELER REVISION #1 Dated 17 January 2012