The Magnet Measurement Facility Business Plan

MEP-TH100705-1 rev

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1.0 SCOPE

The purpose of this business plan is to provide a profile of operations at the Magnet Measurement Facility (MMF). It describes the mission, objectives and resources of the MMF, and provides a structure for how these should be accomplished. It is intended to be of value to MMF staff as a guideline for how to do business; and also to its customers and lab management as an outline of what can be expected from the facility.

2.0 MAGNET MEASUREMENT FACILITY OUTLINE

The Magnet Measurement Facility has provided precision measurement of magnets to Jefferson Lab since the construction of the CEBAF accelerator began in the early 1990's. With over 2500 magnets in the CEBAF accelerator and over 100 magnets in the Free Electron Laser (FEL), the MMF has provided support to a wide range of installations as well as to the scientists and engineers who operate these accelerators.

The daily operation of the MMF involves several activities related to the core focus of delivering precision magnetic measurements to the entire Jefferson Lab community (including Accelerator, Physics and the FEL). Specifically these activities include:

- One time and production magnet measurement
- One time and production mechanical assembly and QC of magnets
- Magnet repair
- Electro-mechanical integration
- Limited accelerator site magnet support
- Instrumentation Engineering

Mission: The mission of the Magnet Measurement Facility is to deliver precision magnetic measurements and related magnet measurement support to the Jefferson Lab community, while maintaining a safe working environment, and providing an opportunity for career growth and technical development for its staff.

3.0 PRODUCTS & SERVICES

3.1 CAPABILITIES

The current measurement stand configuration (Dec 2007) consists of a stepper stand and a rotating coil stand. The stepper stand is used for measuring magnetic fields in a Z,X plane. The existing stand is large enough to accommodate magnets of up to 2 meters in length, and has a positional accuracy of better than 0.004in. Field measurement accuracy is increased by the use of NMR calibrated Hall Probes.

The rotating coil stand is used for multipole measurements of field strength and harmonics. Detailed information on the performance optimization and rotating coil measurement capabilities can be found in TN-06-018.

In addition to the two measurement stands the MMF uses a variety of precision measurement equipment for magnet QC and field measurements. These instruments include:

- Hall Probes
- NMR Probes
- DVM and Transducers
- Hipot Tester
- Electronic Flow Meters
- Electronic Temperature Sensors
- Ethernet connected instrumentation controls
- QC measurement equipment and gauges
- EPICS Controls (WindowsOS based channel access via TCP-IP)

3.2 QUALITY CONTROL

The MMF provides quality control (QC) measurements for magnet components and assemblies. The MMF Group Leader will work with customers to review drawings, punch lists or other documents which will serve as basis for work acceptance. Ideally the inspection requirements would be provided to the MMF staff once the magnet or coil has been designed, prior to bid release. MEG staff must ensure safety is foremost in their designs and that parts are labeled with weights and other pertinent information. Quality control inspection points should be provided on drawings or other applicable documentation.

Typical QC inspections conducted by the MMF will include:

- A hipot test conducted as quickly as possible upon arrival of all coils and magnets into the area.
- A flow test conducted on all coils. Engineers requesting pressure system testing, such as flow tests, are required to provide a testing procedure that meets the requirements defined in the Jefferson Lab EHS&Q manual Chapter 6151.
- In both cases (hipot and flow test) the associated data, date of inspection, and technician conducting the tests, shall be recorded in a spreadsheet format and saved electronically to the MMF m:/ drive directory. An electronic log will be entered into the Magnet Measurement Log Book (Pansophy) and the results passed on to the responsible engineer in a timely manner.
- The standard inspection tag shall be tied to the part including the results of the inspection, pass/fail designation and inspector initials.
- A visual inspection shall be conducted **o**n any part or magnet to ensure that there are no obvious hindrances to its performance. The inspection should also address any potential problems associated with the physical characteristics of the magnet. These inspections should include:
    a. hose fittings
    b. magnet leads

c. wiring configurations/bussing
d. measurement fixturing

In all cases the MMF staff will look for trends and repeated faults. All faults found will be reported to the responsible engineer for evaluation. They shall be communicated with inspection reports and verbal feedback to customers. If repeated faults occur over a prolonged period of time such that the manufacturer is unwilling to correct the fault, the MMF Group Leader or Engineering managers will directly inform the responsible engineer and the procurement department of these specific problems. In addition, other magnet engineers will be informed in the form of lessons learned.

4.0 OPERATIONAL PLAN

4.1 CUSTOMER RELATIONS

All work to be performed by the MMF staff shall be discussed between the customer and the MMF Group Leader prior to the commencement of any work, and will include, as appropriate, the MMF staff and Engineering management. These discussions shall specify the job's technical requirements, scope of work, quantity of work, quality of work and required deliverables while considering safety, resource loading, and work integration with other customers. Tasks which involve more than 1 man-day of effort shall require a written or online work request (see example in Appendix C). A link to the online Work Request form is found on the MMF webpage, www.jlab.org/Magtest. All work, including tasks involving less than 1 man-day of effort, will be documented on the m:drive (data) and in the Pansophy database (task details). In place of a work order an ATLis or FEList entry may be used provided the information outlined in the example is supplied. MMF customers are responsible for providing the documentation to the MMF Group Leader, detailing the requirements agreed to in these discussions. The MMF staff will help customers to understand MMF capabilities according to their needs.

The MMF Group Leader may seek consultation with CASA, Operations, or other internal resources to ensure the deliverables meet the institutional technical criteria and priorities as agreed upon in the documented work order.

Task specifications, including scope and performance, will be detailed prior to beginning any work. If there is a definitive need for scope or performance adjustments, these situations will be negotiated between the customer, MMF Group Leader and Engineering managers. Integral to the justification of the scope or performance adjustment is the manpower and schedule impact on the MMF and its commitment to other priorities. Sufficient float time will be included to allow for scheduling the adjustment. Any project that exceeds the time allotted for project completion will be re-evaluated according to laboratory priorities as defined by engineering management. It is important to note that institutional schedules/priorities shall drive the delivery dates, and not customer derived completion milestones.

Limited field work on the accelerator site may be performed by the MMF staff as requested through a written work procedure or an equivalent ATLis/FEList entry. The written procedure must be delivered to the MMF Group Leader who will coordinate the work accordingly and deliver the finalized documented work plan to Alignment and Metrology Group (AMG) management for review. Technicians must review, understand, and accept any procedure before the work starts.

4.2 PROCECURES

The MMF encompasses a variety of hazards. To reduce the risk of human injury and property damage, Standard Operating Procedures (SOPs) have been developed for several of the activities that are common in the area. All staff members are required to familiarize themselves with and follow these procedures, as well as communicate procedural modifications to the MMF Group Leader where applicable.

Formal and/or informal work planning shall be done for all jobs depending on the level of complexity. Formal work planning for more complex tasks will be in the form of a written procedure. Informal work planning for routine tasks will include thinking through all the steps and safety issues involved with a job and discussions with the MMF group leader prior to starting work. If a modification is required to a planned task, the staff member should ensure that all the steps in the original plan are still appropriate and consider the hazard mitigation necessary for the revised work plan. If informal planned task are repeated several times, then the procedure should be documented so that it can be archived as part of the area work control documents.

All work will adhere to JLab EH&S Manual; specific chapters of interest include, but are not limited to:

Hazard Identification and Characterization	Chapter 3210
Lockout/Tagout	Chapter 6110
Hand and Power Tools	Chapter 6120
Welding, Brazing, Cutting and Grinding	Chapter 6122
Crane and Hoists	Chapter 6140
Compressed Gases	Chapter 6150
Electronic Equipment Safety	Chapter 6230
Static Magnetic Fields	Chapter 6440
Personal Protective Equipment	Chapter 6620
Pressure Systems	Chapter 6151

SOPs associated with MMF area operations must be reviewed by all MMF staff members at the beginning of each calendar year. Additionally, TSOPs are occasionally associated with specific work tasks. When a TSOP is created for a work task in the MMF, All MMF staff must review and sign the TSOP prior to beginning the associated work.

Detail procedures of how the MMF will conduct its work include:

SOP for Magnet Hookup and Operation of a Danfysik Box Power Supply
SOP for the Use of the Baker Hipot Tester in the Magnet Measurement Facility
Daily Shutdown Procedures
Risk Assessment Document

4.3 CALIBRATION & MAINTENANCE

4.3.1 Maintenance - A preventative maintenance plan will be defined for the rotating coil and stepper measurements stands.

There shall also be a QC/maintenance schedule for spare magnets that are routinely swapped out. Such magnets shall be hipot and flow tested on a 24 month basis. All hipot testing in the MMF will require that the worker review and sign the associated Baker Hipot SOP and have appropriate electrical training. Records shall be kept with each magnet detailing the QC tests and dates. Additionally, all QC and maintenance work will be logged in the Pansophy database.

Magnets currently on the schedule include:

- YA - Dipole
- YB - Dipole
- YR - Dipole

Note that these magnets are currently stored in the MMF radiation area mezzanine. Coordination with the RADCON department is required for setting up a radiation work area and moving activated components between areas.

The comprehensive inventory conducted in 2007 shall be kept up-to-date. The inventory shall include: (with as much detail as possible)

1. a listing of all magnet ID's, their quantity and location
2. a listing of all coils
3. a listing of all cores, including their dimensions
4. a listing of all laminations, including quantity and condition
5. a listing of tooling and dies

The MMF Group Leader will be responsible for posting the inventory on the web site for user access.

4.3.2 Calibration - All measurement and test equipment (M&TE) shall be listed and reviewed for inclusion in a calibration program. M&TE includes equipment used to perform or determine inspections, acceptance testing, data collection, process monitoring, maintenance, repair, and calibration of installed facility equipment and instruments. The inclusion of a piece of equipment in the program will be based on the following criteria:

1. Is the equipment used for precision measurements?
2. Is the equipment used for absolute accuracy or repeatability measurements?
3. Can the equipments calibration be verified with another calibrated instrument?

Equipment that is used for non-precision testing and relative measurements will not be included in the calibration program. Equipment that is to be included in the program will be assessed for calibration requirements. These may either be calibrated "in house" or by a vendor. If the equipment is calibrated "in house", a written procedure will be developed and the equipment will be tagged appropriately.

Instruments included in the calibration program will be logged into the Pansophy calibration database. The database will store information about the calibration intervals which will be determined based on manufacturer recommendations, JLab precision requirements, and historical instrument performance.

4.4 SECURITY

Area security is an important priority for the safety and well being of staff and equipment. It is therefore necessary at the end of each day to follow the area shutdown procedures. In general this procedure outlines turning off all power supplies and area lights, and calls for locking all computer screens, cabinets, toolboxes and doors before leaving for the night.

4.5 FUTURE DEVELOPMENT

The major challenge facing the MMF over the next few years will be to provide support for the 12 GeV upgrade of the CEBAF accelerator. This will involve the measurement of approximately 70 new dipoles, 115 new quads, and 160 new corrector magnets. It also involves reconfiguring approximately 300 existing dipoles, and the re-measurement of about 30 existing quadrupoles. The current schedule has the new magnets arriving in FY2010, and the major re-work of existing magnets occurring during a 10 month period in FY2012. In order to accomplish this work, new measurement stands will need to be built and commissioned before FY2010. It is planned that a new stepper stand capable of providing a detailed grid measurement for 4m arc dipoles will be designed and built. In addition, a stand providing a limited grid of measurements will also be required. The rotating coil stand currently in operation is considered sufficient for the 12 GeV quadrupole measurements, although some refurbishments will occur. Together with these hardware developments it is intended to improve the data analysis by making it much more automated, and there will be software development associated with this task. The skills requirements outlined in the following section should be fundamental enough to be valid in an expanding workload situation.

5.0 ORGANIZATION & STAFFING

Since October 2007, the MMF has been part of the Alignment and Metrology Group (AMG). The MMF Group Leader takes direction from the AMG manager, and under his guidance, will lead a team to conduct the various operations and services offered by the facility to its customers.

The Magnet Measurement Facility is currently staffed based on non-production operations. Current staffing has been adequate to maintain consistent throughput of magnet work for JLab during non-production. However, under the current configuration, a number of the skills required for operation of the MMF do not optimally match those of the staff members conducting the work. Table 1 shows the current staff skills breakdown along with an ideal mix of skill sets. Examples of where skills are provided by the specific individual, but can not be expected for their job classification include:

- **Group Leader** – Signal Diagnostics
  Programming
  Electrical Calibration
- **Vacuum Tech** – Programming
  Wiring
  Instrument Calibration
- **Mechanical Tech -** Electrical Calibration
  Signal Diagnostics

To compensate for the skills mismatch and shortfall, the MMF has relied on other groups to diagnose, optimize, and repair equipment used in the magnet measurement lab. These groups include ESDC (electric support), RF (signal diagnostics), and FEL engineering (instrumentation support). Restructuring the group to include a highly skilled electrical technician would improve the group's ability to maintain and improve measurement performance.

Additionally, the general staffing structure in most precision magnet measurement groups includes a PHD Physicist with a background and experience in electromagnetism, magnet design, and magnet measurement. Established procedures and ties to other experienced physicists within Jefferson Lab have allowed the MMF to maintain operations using a different structure. The MMF has successfully utilized engineers trained in magnet measurement as group leaders during its non-production operations. Two viable options exist to improve operations. One would include establishing a more formal union between the existing MMF group leader and another Jefferson lab physicist knowledgeable in magnet measurement and analysis. The second would involve bringing in a highly skilled and experienced magnet expert to lead the MMF efforts and possibly the Engineering group magnet designers.

MMF staff must be able to work well together as well as with customers. The staff must be able to work independently to accomplish specific task assignments that are brought together for an overall project goal. It is possible that one of the technicians may be the line supervisor of the other. Each technician, however, should have the level of responsibility to lead other employees if required.

Specific job descriptions are written in Appendix B

Table 1: Aligning MMF Staffing to Required Skills

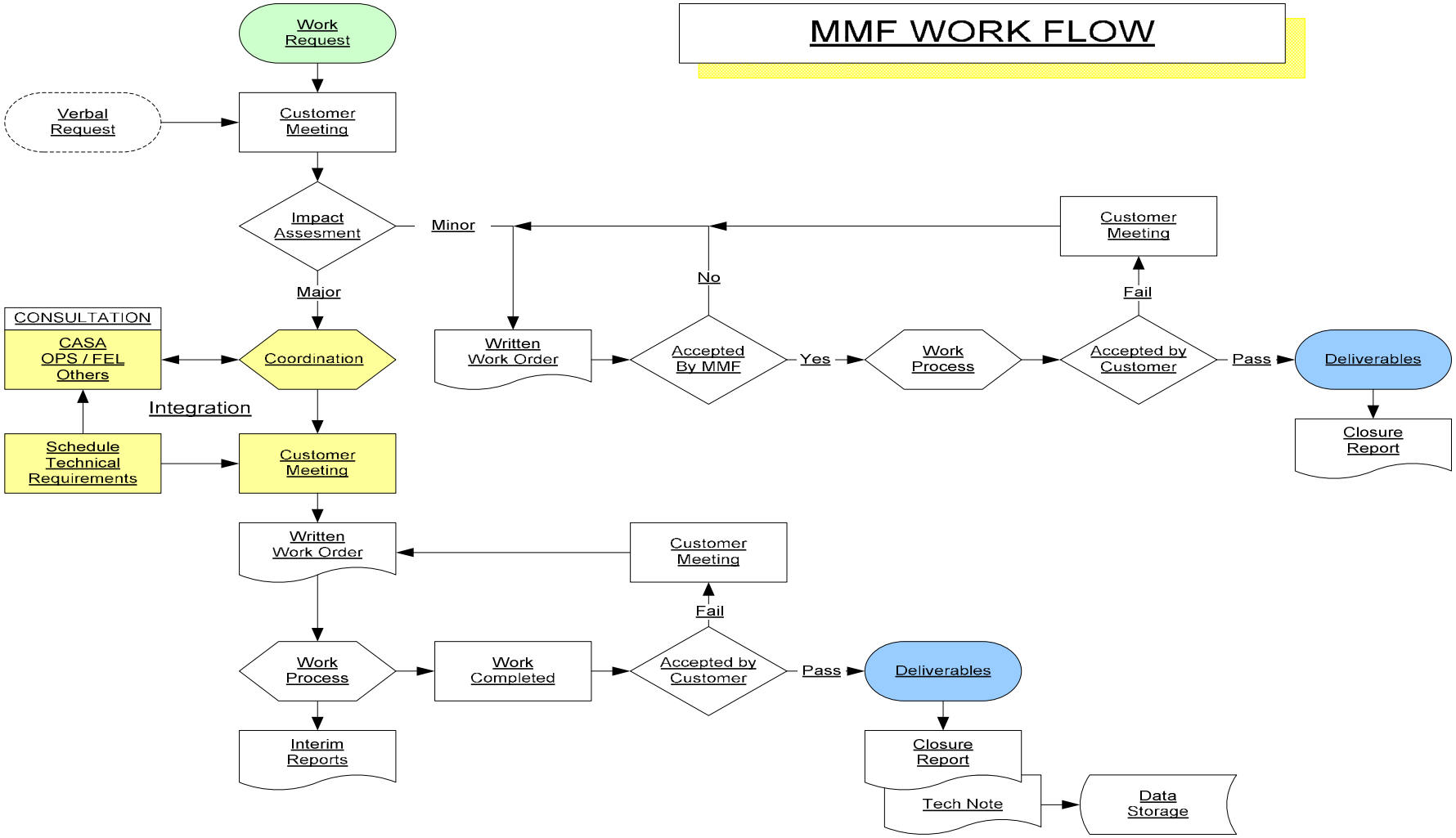
Current Staff
Group Leader (Instrumentation Engineer)
Mechanical Technician
Mechanical Technician (Matrixed out)
Vacuum Technician (part time)

	Magnet Measurement Job Skills Required													
Services	Programming	Wiring	Signal Diagnostics	Mechanical Calibration	Electrical Calibration	Software Operation	Crane and Rigging	Fabrication	Assembly	Alignment	QC	Database Adminstration	Data Analysis	Documentation
Magnet Measurement	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Mechanical Assembly & QC		✓		✓			✓	✓	✓		✓	✓		✓
Magnet Repair		✓		✓			✓	✓	✓		✓	✓		✓
Electro-Mechanical Intergration	✓	✓	✓	✓	✓	✓								✓
Accelerator Site Magnet Support		✓		✓							✓			✓
Instrumentation Engineering/Calibration	✓	✓	✓		✓	✓						✓	✓	✓

Ideal Staff
Group Leader (Instrumentation Engineer II-III)
Electrical Technician (AC)
Mechanical Technician (III)
Mechanical Tech (I)

	Magnet Measurement Job Skills Required													
Services	Programming	Wiring	Signal Diagnostics	Mechanical Calibration	Electrical Calibration	Software Operation	Crane and Rigging	Fabrication	Assembly	Alignment	QC	Database Adminstration	Data Analysis	Documentation
Magnet Measurement	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Mechanical Assembly & QC		✓		✓			✓	✓	✓		✓	✓		✓
Magnet Repair		✓		✓			✓	✓	✓		✓	✓		✓
Electro-Mechanical Intergration	✓	✓	✓	✓	✓	✓								✓
Accelerator Site Magnet Support		✓		✓							✓			✓
Instrumentation Engineering/Calibration	✓	✓	✓		✓	✓						✓	✓	✓

APPENDIX A – MMF Workflow Chart



APPENDIX B - Magnet Measurement Facility Staffing Description

*One of the TD II – AC I positions below may be filled with a TD II – TD III depending on their qualifications.

SS or SE II/III – Magnet Measurement Engineer (Group Leader)
Requirement:
Maintain and encourage an environment of safety and orderliness. Provide oversight and lead a team responsible for all aspects of magnet measurement support. Interact with the AMG manager on issues of budgeting, scheduling and prioritization. Supervise and coordinate personnel to perform magnet measurements and oversee the magnet measurement test stands including data acquisition, hardware and software as well as the development and maintenance of SOPs, TSOPs and other related working documents. Continue a daily dialogue with the area Safety Warden and promptly address all safety related issues. The individual will be responsible for the overall availability and development of magnet measurement stands and equipment, for testing of magnets, interpretation of the test data and investigation of long term performance studies of new magnet designs as well as those already installed and operating. Upon implementation of new DAQ systems, the individual will be responsible for developing, communicating and executing commissioning plans.

Other responsibilities may include the coordination of other engineers and designers on a variety of magnet measurement equipment. Manage an accurate inventory of spare magnets and components, proper documentation and availability reports. The incumbent will serve as a systems integrator between accelerator physicists and engineers to shape the course of the laboratory upgrades and new programs, ensuring physics requirements can be magnetically measured in the Magnet Measurement Facility and developing appropriate systems when necessary.

SE I/II – Instrumentation Engineer
Requirement**:**
Maintain and encourage an environment of safety and orderliness. Develop, maintain and upgrade software and hardware to run multiple DAQ stands. All software is written in C using the National Instruments Lab Windows software package and use GPIB communication protocol. Be intimately involved in the effort to integrate Accelerator control system into the existing DAQ systems. Be responsible for coordinating with the Magnet Measurement group leader to develop commissioning procedures for new or modified DAQ systems or equipment. Be responsible for coordinating the efforts of the EES staff involved in the project. This individual will work closely with the computer center to ensure the MMF computers are secure, up to date and are equipped with the necessary hardware. The individual will setup a consistent data structure for all magnet measurements and will implement a web-based area to access all data. The individual will be responsible for all of Magnet Measurement's web mastering needs. The individual will also function as system administrator for the MMF's PCs, run measurements on all DAQ stands, conduct data file organization, and have some ability to conduct data analysis.

* TD II – AC I - Mechanical Technologist

Requirement:

Maintain and encourage an environment of safety and orderliness. Provide technical support to the mechanical engineering staff. Responsible for the fabrication of precision magnet measurement mechanical equipment and its setup and operation. Perform assembly, modifications and fabrication of magnets as well as mechanical and electromechanical systems and components. Using conventional tooling, inspect subassemblies and components. Take the lead in positioning and aligning components, meeting tight tolerances. Perform quality control on inbound parts documenting and communicating results to the responsible engineer. Demonstrate advanced proficiency in crane use and rigging techniques.

All tasks are accomplished working from verbal, written or graphic instructions. Work with minimum supervision and have the ability to function as a shift leader for the duration of various projects. Be able to run measurements on all DAQ stands while maintaining detailed records of run specifics.

* TD II – AC I – Electronics Technologist

Requirement:

Maintain and encourage an environment of safety and orderliness. The individual will provide a mixture of electrical, computer and mechanical support to the Magnet Measurement Facility. The primary duty will involve hands on electronic work such as wiring various components, electrical signal diagnosis with the use of standard electrical equipment such as oscilloscopes, waveform generators and signal analyzers. In house calibration of electrical components such as current shunts, power supplies and rotating coils. The individual will maintain all measurement probes and when required build new probes by soldering litz wires to probe boards. Assist in the troubleshooting of DAQ equipment on the multipole stand, dipole stand, stepper stand and any future stands built at the facility. Upgrade any electrical DAQ hardware and software for test stands used for the precision measurement of accelerator magnets. Assist in positioning and aligning components, meeting tight tolerances. Perform quality control on inbound parts documenting and communicating results to the responsible engineer.

All tasks are accomplished working from verbal, written or graphic instructions. Work with minimum supervision and have the ability to function as a shift leader for the duration of various projects. Be able to run measurements on all DAQ stands while maintaining detailed records of run specifics.

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Jefferson Lab Magnet Measurement Facility
Work Request

Instructions

Please supply as much information as possible.
General or vague work requests will be held until additional information is received.
If you need to make changes to a work request once it is submitted, please contact Ken Baggett and include the date of the original work request and details of the change. Changes will not be accepted by any other means and technicians will not work on submissions that do not specifically appear on a Work request.

Primary Contact _____

Primary Contact Email _____

Account code to be charged _____

Date Requested _____

Date Required _____

Description of Work to Be Performed:

- **Field Accuracy Requirements:**
- **Field Reproducibility Requirements:**
- **Field Quality Requirements:**
- **Set Currents:**
- **Hysteresis Limits:**
- **Special Requirements:**
- **Quantity:**
- **Safety Issues:**
    - **Radiation Issues:**
    - **Magnet Size/Weight:**