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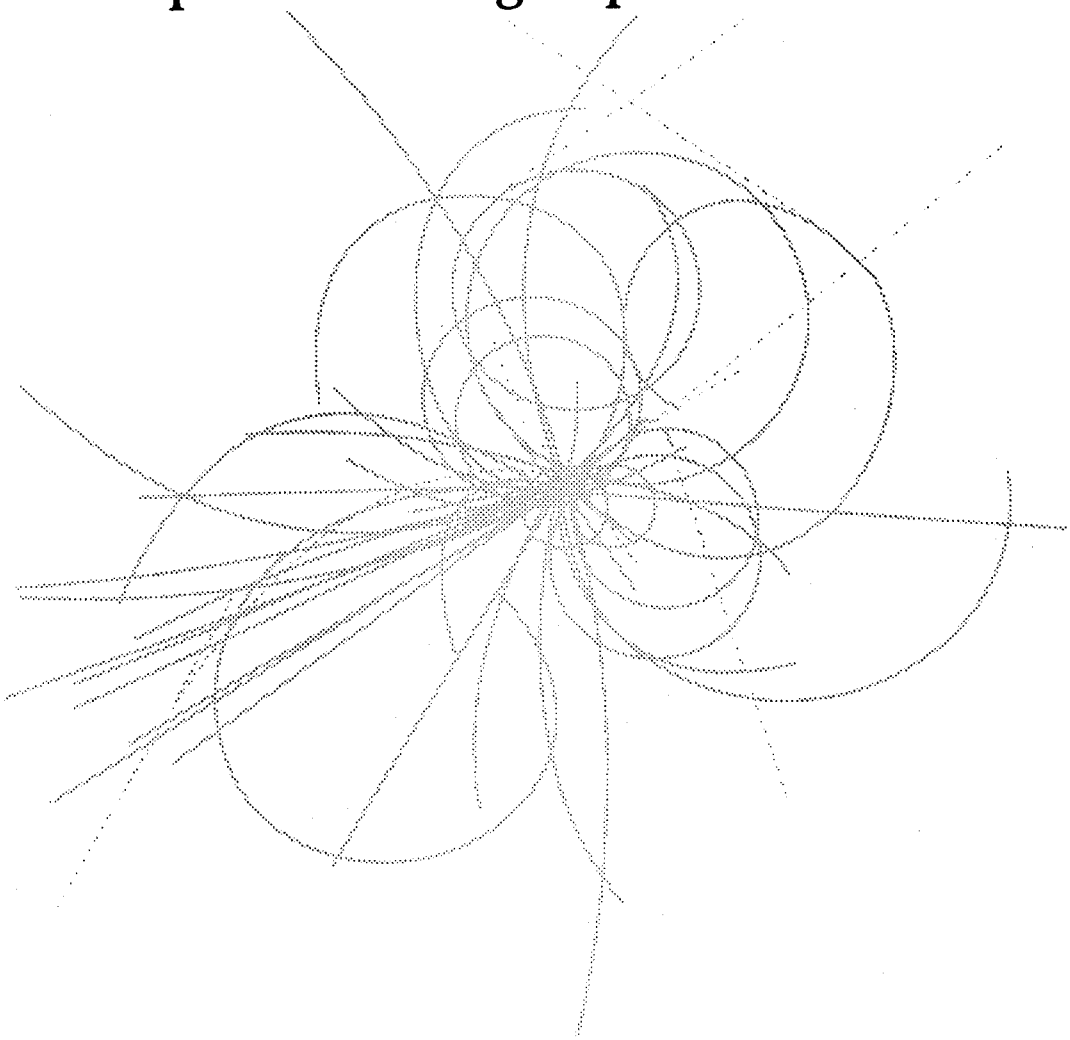
Superconducting Super Collider Laboratory



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SSCL MAGNET SYSTEMS QUALITY PROGRAM IMPLEMENTATION FOR LABORATORY AND INDUSTRY

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ABSTRACT

The development and delivery of reliable and producible magnets for the Superconducting Super Collider Laboratory (SSCL) require the teamwork of a large and diverse workforce composed of personnel with backgrounds in laboratory research, defense, and energy. The SSCL Magnet Quality Program is being implemented with focus on three definitive objectives: (1) communication of requirements, (2) teamwork, and (3) verification. Examination of the SSCL Magnet Systems Division's (MSD) current and planned approach to implementation of the SSCL Magnet Quality Program utilizing these objectives is discussed.

INTRODUCTION

The implementation of the MSD Quality Program is based on the concepts outlined in Department of Energy (DOE) Order 5700.6B. This quality assurance (QA) order provides the policy, objectives, and requirements for magnet programs currently implemented at four National Laboratories (including the SSCL), one foreign laboratory, five industry subcontractors, and more than 100 magnet component suppliers.

The MSD QA organization has been established as a line-management organization reporting directly to the division director. The QA organization is responsible for implementing DOE Order 5700.6B through the QA Implementation Plan. However, the MSD QA Plan embraces all departments of the division by establishment of requirements teamwork

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and of verification policy and procedure. Engineering, production, test, business management, and procurement all play crucial roles in the implementation of Quality Assurance.

Figure 1 reflects the MSD flowdown of DOE Order 5700.6B to magnet and component collaborators and suppliers.

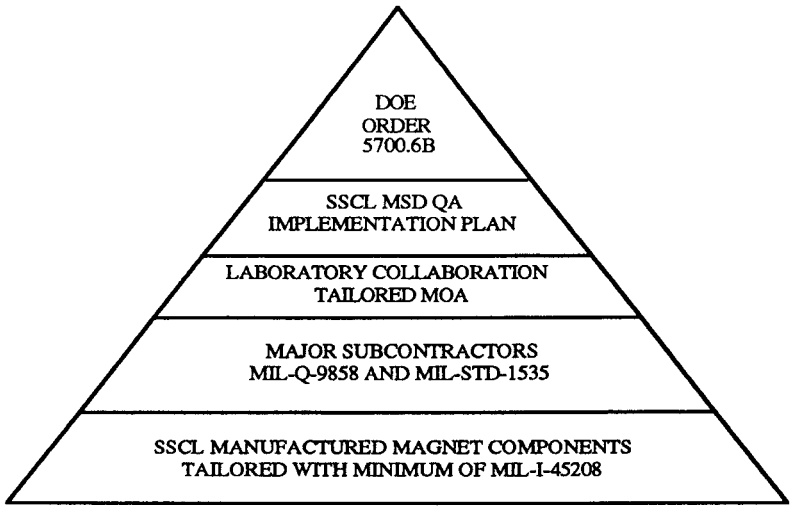

Figure 1. Requirements are implemented to enhance quality, production, and cost-effectiveness while complementing existing systems.

QUALITY IMPLEMENTATION ISSUES

DOE Order 5700.6B is the governing document for the implementation of SSCL Quality program requirements. It is essential that these requirements be disseminated to all applicable suppliers and to the MSD Production Department. The question is how to implement 5700.6B requirements that enhance quality, production, and cost-effectiveness while complementing systems already in place at National Laboratories and at industry magnet and component suppliers.

Within the National Laboratories, systems exist that facilitate research and development programs and are not necessarily geared for extended production of the same product. However, due to a low turnover in personnel (resulting in excellent management and highly qualified technical personnel) and an established supplier base, research and development programs are completed with satisfactory results.

Industry has experience in extended production runs and as a result utilize various systems to control the baseline standard and end product. Industry, especially those firms with large defense or energy program experience, have an extensive background in a MIL-Q-9858 Quality Assurance Program environment.

Potential magnet component and tooling suppliers have been found to have a wide range of experience with systems and process controls, ranging from ASME code requirements through MIL-I-45208 to no system at all. The challenge is to implement systems that the supplier understands (that complement the present system), enhance quality and production, and are also cost-effective.

Experience has shown that it is sometimes easy to implement an extensive list of QA requirements, but the result is not always cost-effective or productive. The MSD QA programs are designed and implemented after an analysis of requirements intended by DOE

Order 5700.6B. Communication of these tailored requirements through a team environment, along with effective verification of results, is the desired objective.

LABORATORY APPROACH

The SSCL, in collaboration with Brookhaven National Laboratory (BNL), Fermi National Accelerator Laboratory (FNAL), and Lawrence Berkeley Laboratory (LBL), has established programs for the successful development of superconducting magnets. The implementation of these programs is through Memorandums of Agreements (MOA) that identify the research and development requirements for a given fiscal year.

The QA programs for this effort are based on an assessment of technical risk and are developed into a series of work statements that consider applications of DOE Order 5700.6B. The statements are chosen to fill essential needs in the QA program to enhance quality—yet permit productivity and cost-effectiveness—while complementing existing institutional QA systems.

Each of the SSCL programs for MSD at BNL, FNAL, and LBL is tailored through the MOA. The laboratories agree to specific QA requirements for the duration of the MOA. The laboratories and assigned SSCL personnel perform the tasks that fulfill the requirements. Common quality tasks at each lab are configuration management, calibration, process documentation, test, and problem reporting.

MSD has assigned SSCL QA engineers and/or technicians to assist in the implementation of Quality Assurance program requirements at the laboratories. In all cases these QA personnel are integrated team members in the laboratory workforce and have verification authority. Periodic SSCL audits are accomplished as added assurance that established MOA requirements are being properly implemented.

The current industrialization[1] concept, which integrates the major magnet subcontractor personnel from General Dynamics, Westinghouse, and Babcock and Wilcox at FNAL, BNL, and LBL, respectively, allows the QA personnel from these major manufacturers to gain early magnet production experience. This industrialization concept assists in establishing these manufacturers as suppliers of superconducting magnets. The industrialization has been implemented in two phases. The first, technology transfer, takes place when the collaborating laboratories provide instruction to subcontractor personnel in the form of lectures, seminars, and hands-on instruction on technology transfer magnets. The second phase allows subcontractors to produce prototype magnets with laboratory oversight. This concept ensures that subcontractors have acquired the necessary skills and knowledge to enter into the next manufacturing stage at specific subcontractor sites.

The SSCL also has development and manufacturing responsibility for model and production type magnets to be built on-site. A quality system to support these internal programs has been implemented through the MSD Quality Implementation Plan as derived from DOE Order 5700.6B.

An analysis of potential DOE Order 5700.6B QA flowdown criteria to smaller suppliers of magnet components was performed in an effort to enhance quality, production, and cost-effectiveness, while complementing the existing QA systems of these suppliers. A survey of smaller suppliers identified MIL-I-45208 as a common QA document. Most suppliers had little or limited knowledge of what was required by NQA-1 or ISO series QA criteria. In fact, more than 80% of all surveyed laboratory suppliers were familiar with or had implemented QA plans requiring MIL-I-45208. Based on this assessment, MIL-I-45208 has been established as minimum QA criteria for MSD magnet and tooling component suppliers. However, MSD has established, by exception, provisions to qualify suppliers based on historical performance and existing QA systems.

The development of a qualified supplier base and methods to verify supplier performance have been elements in the implementation of the MSD QA Program. Procedures and policy have been developed to implement criteria requiring procurement only from qualified suppliers listed on the MSD Approved Supplier List (ASL), QA survey of new suppliers, QA source/receipt inspections, QA review of all requisitions for magnet and tooling components, a certified QA auditor program, and a supplier performance rating system to assist in the recognition of quality products and continuous improvement of substandard products.

Communication of requirements has been a priority with each new procurement. However, an effort is underway to emphasize development of a team member environment with all our suppliers. To accomplish this task we are revalidating our procurement process to provide better up-front communication of requirements with team members and to establish QA follow-up surveillance at the time of contract award for development of new or complex products.

INDUSTRY APPROACH

For complex systems, such as the superconducting magnets, the SSCL has chosen to impose a MIL-Q-9858 requirement. MIL-Q-9858 (titled Quality Program Requirements) is extensively used and well known to industry, particularly to those major contractors involved in defense or aerospace business. Within the framework provided by MIL-Q-9858, General Dynamics has developed a Magnet Quality Program for the collider dipole magnets (CDM).

The focus of the General Dynamics Magnet Quality Program is prevention of product defects. To facilitate the prevention of defects in all phases, the Magnet Quality Program approach has been designed to:

- Develop quality-conscious attitudes and disciplines in all personnel working on superconducting magnet programs.
- Establish cost-effective plans and systems to support magnet verification and assurance activities.
- Involve our suppliers as essential members of the team by building long-term relationships.
- Ensure that all collider dipole magnets satisfy the requirements of the SSCL.

Actively maintaining quality-consciousness among magnet personnel is facilitated by an on-going training program and continuous management support. The first step is to attract a very special workforce of individuals who operate as a team and view quality as an essential part of their job. General Dynamics has utilized a candidate screening process that assures potential magnet personnel are qualified and dedicated. This screening process includes personnel interviews as well as assessment center evaluations. It was used to select the team of technicians and engineers hired to build the Industry Demonstration magnets at FNAL.

Magnet factory personnel will complete an extensive training program. The first 160 hours is provided at the Hammond Area Vocational School, a few hundred meters from the General Dynamics facility in Hammond. The curriculum includes superconducting magnet basics, quality assurance policies and practices, safety, team-based work organization and decision-making, metrication, cleanliness, statistical process control, and defect prevention.

Following the training at the Vocational School, job offers are tendered to those candidates believed to have the technical and interpersonal skills to be successful in the General Dynamics team-based work environment. These individuals then receive additional training in the specific job function to which they are assigned. Successful completion of this training is required prior to hands-on factory work. Refresher training is scheduled at

intervals consistent with the goal of assuring that quality consciousness and awareness remain at a high level throughout the CDM program, and when individual performance indicates the need.

To facilitate cost-effectiveness, the General Dynamics Magnet Quality Assurance (MQA) organization has performed a thorough review of program requirements. All quality requirements are planned in conjunction with all other affected functions, such as production, engineering, and procurement. The MQA personnel are co-located with the magnet production and engineering personnel in the program team area. They actively participate, along with designers, manufacturing engineers, and analysts, on the concurrent engineering teams charged with the responsibility of developing the final design of the collider dipole magnet (Figure 2). Quality engineers have participated in all aspects of the technology orientation sponsored by the National Laboratories and product development. Through this approach, they have attained first-hand technical knowledge of the program and are aware of the critical elements.

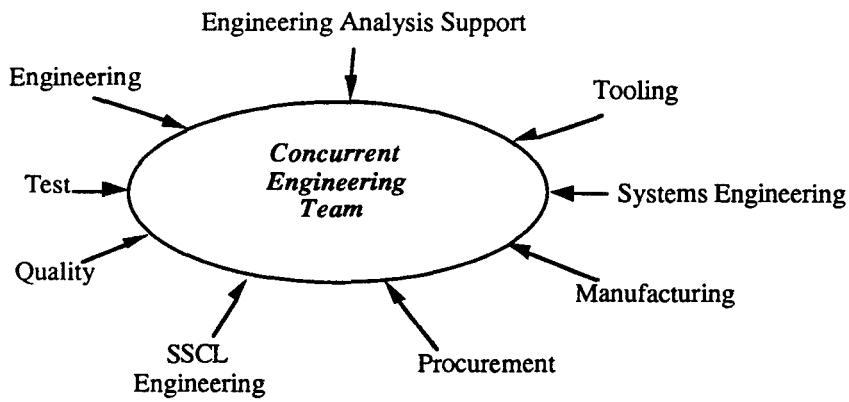

Figure 2. Quality Assurance actively participates in concurrent engineering.

The validation and verification process emphasizes process control to assure performance requirements and to attempt to maximize yield. Automated and computer-aided quality verification and data collection systems are being developed and implemented where cost-effective.

General Dynamics requires full and responsible participation by magnet component and tooling suppliers, and encourages a partnership relationship with them. A number of major tooling suppliers are currently under contract with the company. These contracts feature emphasis on supplier communication not only with General Dynamics, but also with other suppliers who will supply interfacing tooling or hardware.

For superconducting magnet programs, the General Dynamics objective is to assure that responsibility for the quality of products and tasks rests with each person doing the work and with supervision/management. Quality is not the sole responsibility of the Quality Assurance organization; each employee's effort to provide a quality product, whether or not he directly handles parts, is essential to assure a successful program.

SUMMARY

The SSCL Magnet Systems Division has implemented a structured approach—derived from DOE Order 5700.6B requirements—to assure that magnets will be reliable and producible. These requirements are communicated within the National Laboratories and to industry by flowdown through the SSCL MSD QA Implementation Plan.

The quality program implementation has been tailored to be a cost-effective approach to achieving program requirements. Appropriate verification has been designed into the quality program, with emphasis on the development of a team environment between the SSCL Magnet Systems Division, collaborating National Laboratories, and industry.

REFERENCES

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