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QUALITY ASSURANCE MANUAL *

Volume I

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INDEX VOLUME I

1. G E N E R A L

1.1 SLAC Quality Assurance Policy

Stanford Linear Accelerator Center (SLAC) is a DOE-supported research facility that carries out experimental and theoretical research in high energy physics and developmental work in new techniques for particle acceleration and experimental instrumentation. The purpose of this manual is to describe SLAC quality assurance policies and practices in various parts of the Laboratory.

The General Quality Assurance Policy for SLAC is the following:

1. Excellence of research and technology is a primary goal of SLAC.

2. It is the policy of SLAC to assure the quality of its tangible products.

3. The extent of the systems used to assure quality depends on the nature of the products.

   a. The quality of the products of research will be assured through the scientific peer review process.

   b. The quality of manufactured products made singly or in limited quantity will be assured by adherence to published standards and procedures.

   c. The quality of products manufactured in a full-scale production environment will be assured by an extensive quality assurance process.

4. Responsibility for excellence of quality is vested in the SLAC line management, including project managers.

5. The Associate Director, Technical Division, shall be responsible for establishing and reviewing Laboratory quality assurance standards, procedures and systems.

6. Neither the safety of any individual nor the expediency of any emergency repair shall be compromised by unthinking adherence to quality assurance systems.

1.2 The Scope of the Manual

The main purpose of the Laboratory is research in high energy physics. The Laboratory is divided into three separate divisions:

- 1. Technical Division
- 2. Business Services Division
- 3. Research Division

The following breakdown of types of operation is used in this manual:

1. Engineering and Manufacturing Operations:

- Mechanical Systems Department
- Klystron Department
- Electronics Department
- Plant Engineering Department
- Accelerator Department (portions of department)

These departments in the Technical Division have the responsibility for practically all production and manufacturing at SLAC. This includes machining, assembly, test, inspection, and installation functions as well as design and engineering. Quality assurance practices are an integral part of the operation of these organizations, but individual plans and procedures differ.

2. Accelerator Physics and Particle Physics Research:

- Accelerator Department (portions of department)
- Accelerator Theory & Special Projects Department
- Research Division (Experimental Facilities Department and Special Projects)

Particle physics and accelerator physics research and development are carried out in these two Technical Division Departments and in the Research Division. Quality is assured through an extensive peer review process - both inside and outside the Laboratory.

3. Business Services:

- Business Services Division

This division performs various support functions for the rest of the Laboratory to assist in daily operation. The Purchasing Department, which acts as an interface between outside suppliers and customers in the Laboratory, is discussed in more detail in section 2.8.

2. QUALITY ASSURANCE IN THE LABORATORY

2.1 General

For most of this manual quality assurance is discussed within the following framework:

1) Organization
2) Design Control
3) Incoming Material Control
4) Product Control (Production, Operation, Maintenance, etc)
5) Quality Information

The chapters in this manual describe quality assurance in various parts of the Laboratory. Appendices include relevant procedures, standards, documentation, and other important quality information.

2.2 Mechanical Systems

2.2.1 Organization

The organization chart for Mechanical Systems is shown in exhibit 2.2.1. There are four separate groups:

1) Mechanical Engineering and Alignment Department
2) Design Group
3) Vacuum Group
4) Mechanical Fabrication Department

These groups all interact closely on a continuing basis, and the coordination of different activities is of major importance. Normally, designers and engineers are assigned from their own groups to various user groups. This assignment may be to one of the Mechanical Systems groups, to a specific project, to another Laboratory group, or to an outside group.

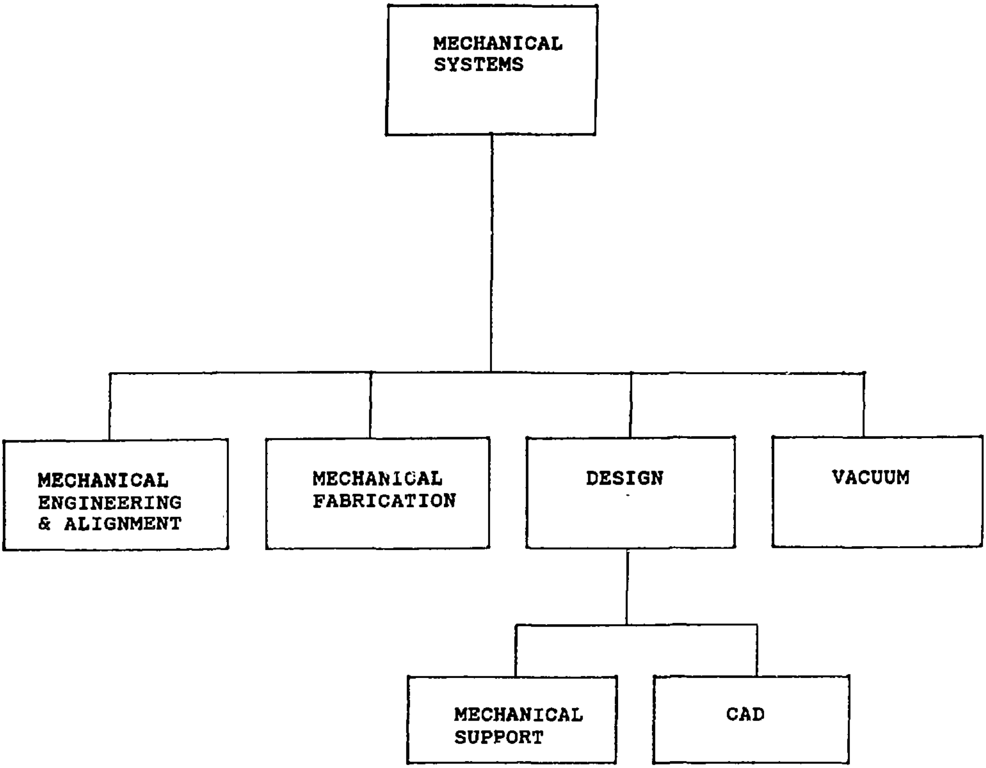
2.2.2 Quality Assurance in Mechanical Systems

2.2.2.1 General

Since the quality of the final product is a sum of all the activities within the department - initial design, detailed design and drafting, fabrication, and when pertinent installation and maintenance - quality assurance in Mechanical Systems is a matter of coordination and follow-up of established procedures and standards. Mechanical Engineering, Design, and Vacuum are responsible for design and drafting. Mechanical Fabrication is responsible for the tooling, fabrication, and assembly. Some assembly also takes place in the Vacuum Group. In addition, both Mechanical Fabrication and Vacuum perform installation and maintenance. The Mechanical Support Group, which is under the Design Group, performs mechanical installation jobs in the accelerator.

In the following sections, the whole organization is discussed as one unit following a standard breakdown of functions - Design, Incoming Material and Product Control, Production and Operation, and Quality Assurance Information Systems.

Exhibit 2.2.1


MECHANICAL SYSTEMS
MECHANICAL ENGINEERING & ALIGNMENT
MECHANICAL FABRICATION
DESIGN
VACUUM
MECHANICAL SUPPORT
CAD

2.2.2.2 Design

Mechanical Engineering, Design and Vacuum have implemented a policy to assure consistency and quality of mechanical design work. This policy states clearly different aspects of mechanical design, and is shown in Appendix A.1. The policy covers all equipment for all machines of the accelerator complex. Designs of all other equipment are reviewed by responsible engineers.

Industry standards and widely accepted practices are implemented in design and engineering. In addition Laboratory standards and procedures are used (appendix A.2). The Standards Group of SLAC continuously makes additions and revisions to these existing standards.

Documentation requirements are defined by procedures and standards (appendix A.2). Adequate documentation and print quality are assured through clearly stated procedures and sign-off responsibilities.

Continuous interaction between the design groups and the Mechanical Fabrication Department (MFD) is essential in the early stages of the design process. The emphasis is on minimizing the number of design revisions before final fabrication. A large portion of the design workload is prototyping and one-of-a-kind in nature, which means that it is necessary to control the whole design-manufacturing process rather than trying to control the quality of the final product through extensive quality control and check programs.

Quality assurance policies and procedures of the Alignment Group (under Mechanical Engineering) are discussed in Appendix A.3.

2.2.2.3 Incoming Material and Product Control

Incoming material and products arrive through the Purchasing and Shipping and Receiving Departments. The Purchasing Department has its own procedures and standards covering incoming material and product control (see Purchasing, section 2.8).

Usually materials are ordered to specifications, and vendors provide information about the properties and other relevant factors. Normally, all materials must be purchased to an ASTM or other approved equivalent specification. All incoming materials also go through an extensive visual check process. In most cases this is an adequate process to assure the quality of the incoming material.

In some cases, when the material requirements are higher (e.g., for ultra high vacuum, klystrons) the incoming materials go through a more extensive chemical or metallographic testing.

Original mill source certifications must be obtained, and they must include the heat number and the results of chemical analysis and mechanical properties tests. Critical parts are numbered and recorded indicating the lot numbers of incoming materials to assure the material traceability throughout the whole manufacturing process.

2.2.2.4 Production

The Mechanical Fabrication Department (MFD) consists of eight production shops, each managed by a different supervisor:

1. Precision Assembly Shop
2. Metal Finishing Shop
3. Light Machine Shop
4. Heavy Machine Shop
5. Structural Welding and Sheet Metal Shop
6. Assembly Shop
7. Central Laboratory Machine Shop
8. Test Laboratory Machine Shop

These production shops perform jobs for various user groups, and each supervisor is responsible for the work produced in his shop. Work is performed according to prints following industry standards and procedures as applicable.

The MFD Manufacturing Engineering office serves as an interface between the design (customer) and the actual manufacturing of parts. This office is the first to raise questions of manufacturability and functionality of designs to minimize the number of engineering and design changes during fabrication. Furthermore, shop supervisors raise questions regarding manufacturability to the Manufacturing Engineering office to clarify instructions and to make suggestions. Attainable tolerances, material compatibility, and similar requirements are also evaluated by a Quality Control group in the MFD.

The Assembly Group has an important function in setting up the actual production. It has the following major duties:

1. Make fixtures, set procedures, and prepare travelers as necessary.
2. Review tolerances for assembly fits.
3. Store as built parts, subassemblies, fixtures, and spare parts.
4. Prototype and develop first run instruments prior to production.
5. Provide a practical interface with other groups following, accepting, and disseminating their procedures.
6. Record actual assembly steps taken including deviations to create a product assembly history.
7. Store and inventory piece parts for release to other groups.

The Quality Control Group creates, distributes, and files compliance reports, as well as red-lines prints and work files to return to engineering and design for necessary revisions. The Manufacturing Engineering office updates older prints for changes in materials required for outside purchase. Particular attention is addressed to current safety and material specifications. Also, the Manufacturing Engineering office returns sketches of new tooling to be properly documented by engineering and design.

Quality of fabricated parts and conformance to the requirements and specifications is normally reviewed to a degree the customer requests. Routinely, parts are visually inspected and counted before release. The Quality Control Group reviews parts, returns non-spec parts to responsible shops, and makes technical suggestions to solve fixturing and tooling problems. Machine quality is assured by the Machine Repair Group, which performs mechanical and electrical overhauls and repairs, as well as alignment and calibration of tools (shop floor tools, personal tools, instruments, etc.).

The main tool of shop floor control documentation is a shopwide control sheet, which follows different stages of manufacturing. Individual travelers are also used. In addition, supervisors have a variety of record-keeping systems, including:

a) logbooks
b) time card files
c) print files (paper and microfilm)
d) priority sheets
e) computer data bases for various uses

Material and work traceability is important, and it is reflected in these different systems. Appendix A.4 shows examples of some common record-keeping systems in production.

The Vacuum Group has published its own standards and procedures in Technical Specification for Vacuum Systems and List of Vacuum Notes (SLAC TN-86-6). These cover design, installation and operation of vacuum components and systems. Examples of documentation in production are included in Appendix A.4.

Procedures for mechanical installation and maintenance operations are covered in Appendix A.1. Examples of more detailed installation and removal procedures are shown in Appendix A.5.

2.2.2.5 Quality Assurance Information

All the documentation serves a quality information purpose. However, the main informational tools are the standard shop floor control system, reports from the Quality Control Group, status reports, and different review meetings. A weekly status report of the Manufacturing Department is shown in Appendix A.6.

Design reviews and meetings between design and manufacturing groups provide important quality assurance information. During production different types of quality checks (visual checks, tooling, material tests, etc.), especially the ones performed by the Quality Control Group, indicate how well the production process conforms to requirements. Customer satisfaction and feedback often give a further measure of achieved conformance.

Meetings between workers and supervisors, and between different levels of managers from various groups serve as an information and coordination tool as well as a form of a quality circle. These meetings, which are held on a daily, weekly, and monthly basis, summarize current work status as well as solve problems in all areas of operation.

2.3 Klystron & Microwave Department

2.3.1 Organization

The Klystron & Microwave Department is relatively small, consisting of four groups (Exhibit 2.3.1):

1) Manufacturing
2) Testing
3) Microwave Engineering
4) R&D

2.3.2 Quality Assurance in Klystron Department

2.3.2.1 General

Klystron production (design, manufacturing, and testing) has a well defined and controlled quality assurance process. The nature of the product requires a work force of well trained professionals with a strong commitment to high quality work. The main quality assurance task in the Klystron Department is assuring that requirements and policies are followed correctly and that corrective actions are taken when necessary. The whole system relies on established procedures and traceability of work and materials.

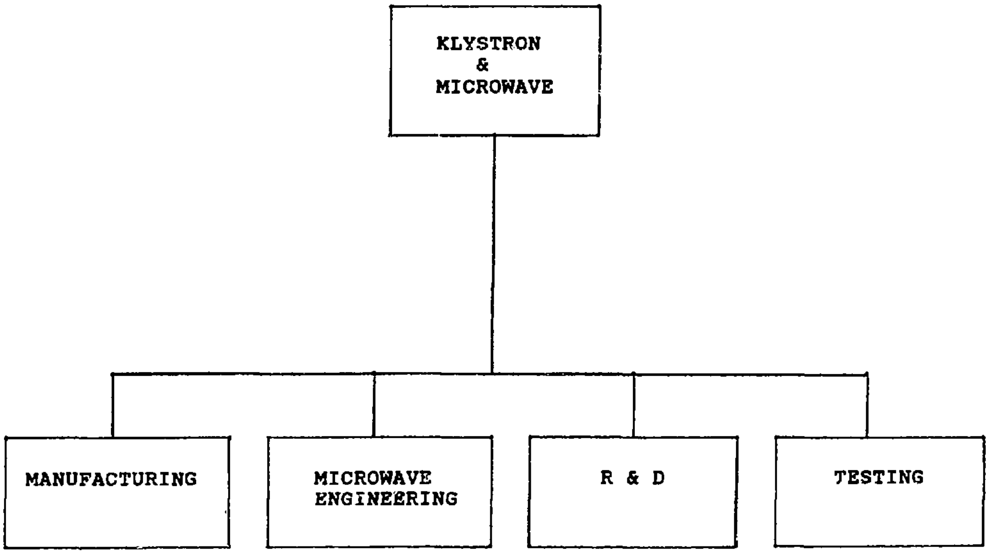
2.3.2.2 Design

Design in Klystron Department is primarily for modification to existing system designs. Formal engineering change orders are required every time existing designs are modified (an example of an engineering change order is shown in Appendix B.5k). This process is carried out in close interaction with the manufacturing and testing groups. Extensive prototyping and testing are performed before new designs are approved to assure functionality and manufacturability of new designs.

2.3.2.3 Incoming Material and Product Control

In the klystron production, all critical materials have to go through a thorough review process. All critical incoming materials are tested (chemicallly or metallographically), certified, and numbered. Appendix B.1 explains in more detail the normal quality assurance procedures for incoming materials. Incoming components (mainly pulse transformer tank and focus magnet) go through extensive testing before assembly.

Exhibit 2.3.1


KLYSTRON
&
MICROWAVE
MANUFACTURING
MICROWAVE
ENGINEERING
R & D
TESTING

Documentation requirements are defined in detailed procedures for incoming materials. When required materials and parts are numbered and recorded in the files to maintain a complete material traceability. Examples of documentation are shown in Appendices B.5a-c.

Materials and components that have been found to be sub-standard are reviewed by a Material Review Board. Items are discussed and reviewed for possible repair, retrofit, or scrapping. Parts that are not clearly suitable for rework are scrapped.

The Klystron Department maintains and updates its vendor list on a continuous basis. For most materials and parts there are multiple potential vendors to assure a continuous and reliable supply.

2.3.2.4 Production

Klystron production consists of tube manufacturing (fabrication, tube assembly, bake processing, and mechanical assembly); klystron assembly (tube, focus magnet, and pulse transformer tank) and testing. Appendix B.2 summarizes quality assurance procedures during different stages of tube manufacturing. Appendix B.3 explains in more detail quality assurance in the fabrication process of individual components. Finally, Appendix B.4 describes the standard quality assurance procedures for klystron testing. All these stages are tightly controlled, and the quality of the product is reviewed several times at each stage.

A standard documentation covers all stages of production. Test procedures, mechanical procedures, manufacturing notes for assembly, computer controlled bake out procedures, and detailed assembly procedures for tube preparation are extensively documented. Material and work traceability are emphasized in the documentation process. Examples of the documentation for klystron production are shown in Appendix B.5. This Appendix includes an almost complete set of documentation in the case of an individual part (anode housing) from the material specifications through production and testing to a failure report in operation.

2.3.2.5 Quality Assurance Information

The documentation covering all the operations within the department is extensive and has been discussed earlier. Another information tool for both management and workers are meetings. Klystron production has daily morning meetings, weekly management reports, and weekly production meetings. In addition to this, individual managers and supervisors are required to meet with their employees at least every other week to review current progress, production goals, yield statistics, and changes in production procedures.

The yield of klystrons (the number of assemblies passing the final inspection divided by the total number produced) is measured, charted and displayed periodically. This serves as an information tool for the management (trend analysis), and at the same time as a motivational factor for the workers.

2.4 Electronics Department

2.4.1 Organization

The organization chart of the Electronics Department (ELD) is presented in exhibit 2.4.1. It consists of five groups:

1) Quality Assurance - provides QA services internal to ELD, and external on request

2) Electrical Support - provides electrical engineering design, hardware and cable installation, and heavy electronic and cable fabrication services

3) Protection Systems - responsible for the Laboratory personnel protection systems. Provides other electronic design support as requested.

4) Electronic Instrumentation - provides electronic engineering support, primarily for experimental detectors.

5) Electronics Services - provides electrical/electronic CAD based drafting, fabrication/assembly, and bench testing services for the Laboratory.

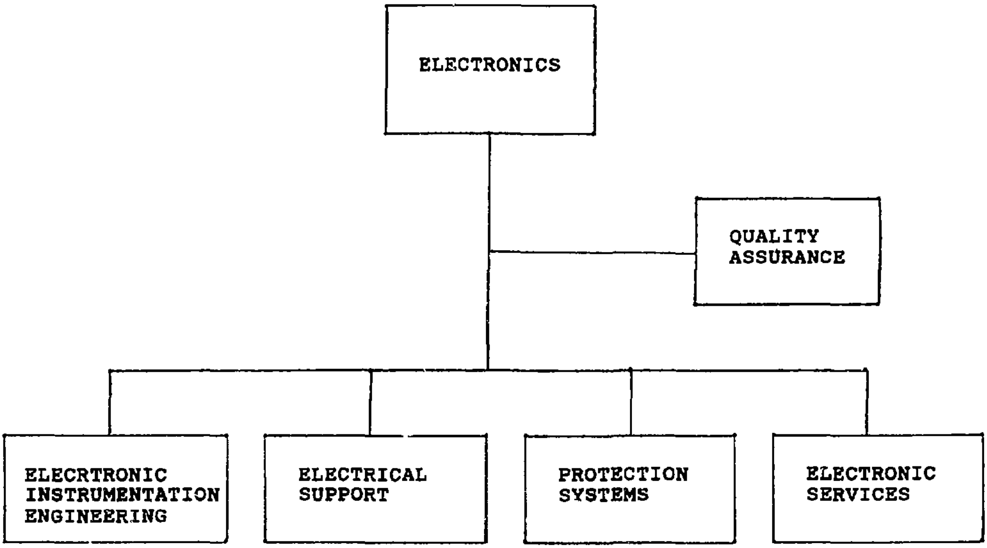
2.4.2 Quality Assurance in Electronics Department

2.4.2.1 General

There are three major areas of quality assurance in the Electronics Department. Quality engineering is performed during the engineering phase of a product to assure that it satisfies specified requirements, will provide the necessary reliability and maintainability after installation in the operating environment, and that it meets the prescribed standards. The group leader of each engineering group is responsible for scheduling the necessary design reviews with the appropriate knowledgeable persons to assure these goals. The results of design reviews are formally documented.

Quality assurance of fabrication is performed during the fabrication process of all hardware by the Electronic Services group. This is required for both in-house and contractor production. Parts inspection, board and chassis inspection and completed assembly inspection are included in this activity to

Exhibit 2.4.1


ELECTRONICS
QUALITY ASSURANCE
ELECRTRONIC INSTRUMENTATION ENGINEERING
ELECTRICAL SUPPORT
PROTECTION SYSTEMS
ELECTRONIC SERVICES

assure conformance to engineering specifications and standards. Records are maintained for use in improving processes and techniques.

Quality assurance of installation is performed during the field installation of all electrical/electronic hardware by designated, trained personnel. Placement of hardware and cables, termination and dressing of cables, and conformance to engineering specifications and standards are included in this activity. The necessary records are kept for future reference.

A Quality Engineer position within the Electronics Department coordinates, monitors, and audits all department quality assurance activities. This service is also available on request to customers in other departments. This position reports directly to the Electronics Department head.

The typical job flow within ELD is shown in Exhibit 2.4.2.

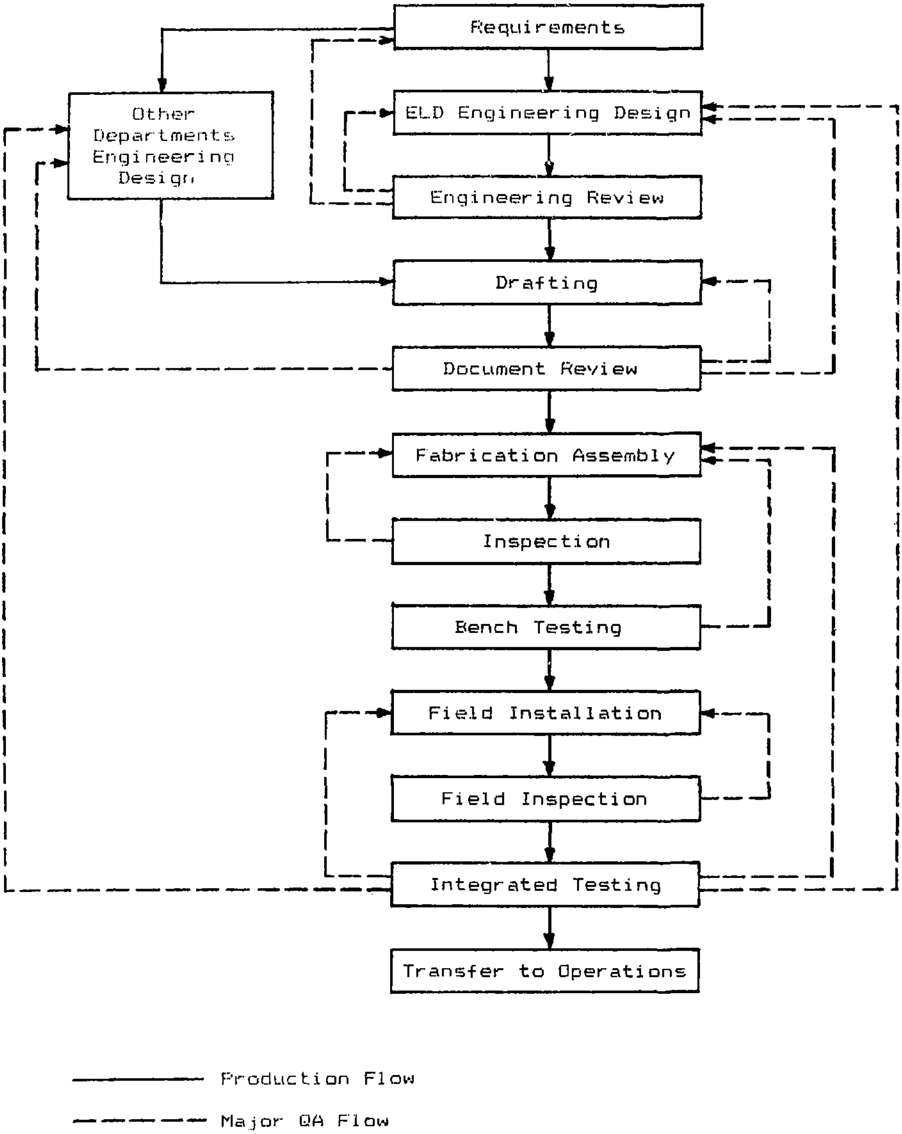
2.4.2.2 Design

All equipment designs go through a formal review process before they enter the fabrication process. This review process addresses the conformance of the design to good engineering practices, accepted SLAC and other industry standards, and safety standards. A list of ELD procedures and standards is shown in Appendix C.1. Some of the standards in Appendix A.2 also apply in the ELD. Each engineering group leader has the responsibility to assure that the design of proposed equipment and installations, starting with the conceptual design phase, are reviewed prior to authorization of detailed design and are reviewed again prior to construction. If required, the approval of other committees such as Hazardous Experimental Equipment Committee (HEEC) is obtained at this time.

At the time of detailed design, the responsible engineer, the Group or Project Leader, and the Quality Engineer must sign off on the design package. The ELD shops do not accept work until the appropriate signatures are present.

The majority of new design work is performed on the CAD system. Together with the established sign-off review procedures, this assures that drawings and other documentation follow standard and approved engineering practices. Also, any other drawings and documentation have to be complete and correct before shops can start the actual fabrication or installation. In addition, all design revisions and modifications must go through the formal process and be recorded in the files.

Exhibit 2.4.2. Job Flow in ELD



2.4.2.3 Incoming Material and Product Control

Materials and parts are either purchased directly from selected vendors, come through the Purchasing Department, or are supplied by the fabrication shops (e.g., from the MFD shops). The general rules of the Purchasing Department apply for the incoming materials and parts (see section 2.8, Purchasing).

A preferred list of vendors is maintained and alternate vendors are provided to assure adequate, timely and reliable supply. Most standard parts and materials (resistors, capacitors, etc.) are kept in stock. Normal incoming quality control is visual checking.

2.4.2.4 Production

Fabrication and assembly in the Electronics Production and Coordination Shop (EPC) follow standards and written procedures (see Appendix C.1). A review is held at the level of checkout of the fabricated equipment. All the units coming from fabrication/assembly are inspected by the QC department of the EPC shop, and returned for corrections if necessary. After units come from fabrication/assembly they go either to testing or they are installed in the field. In the latter case, quality assurance checks are performed by two different groups; one by a field inspection team which inspects the installed cables, racks, AC and support services; and another one by an engineering test team which checks out the final installation. This latter test includes a test of both manual operation and, as appropriate, computer simulation. The engineering groups are responsible for the work until signed off by the group responsible for maintenance. This maintenance group is not formally required to accept responsibility until all phases of the task are complete, including adequate test documents and signed drawings. This reinforces the requirement that installation and testing be done to a high standard, that the equipment performs to the specifications, and that the documentation is accurate and complete.

Throughout the entire production flow, a full documentation package is required to follow from the design all the way to installation and release to a customer. Examples of standard documentation are shown in Appendix C.2. Normally, sign-off sheets are required at different stages, and any problems and design changes are recorded and reported back to drafting and design. This assures that drawings are filed in the Document Control in the Plant Engineering Department "as built." Also, a test document must be written by the responsible engineer and used in the Laboratory testing of the equipment. After testing, the engineer and/or appropriate test technician must sign that the testing has been performed. Although all the new production must conform to these procedures, some of the installed equipment at SLAC is under an ongoing improvement program to correct deficiencies and to provide correct documentation.

2.4.2.5 Quality Assurance Information

Different reviews and inspections as described earlier along with a standard documentation system form the basis for the ELD quality assurance information system. Management performs frequent laboratory, shop, and field inspections, and follows up on reported problems. Feedback from customers serves as an important quality assurance tool.

A weekly status report from the shops serves as a scheduling and information tool. Weekly meetings are held to discuss internal scheduling and problem solving issues. Another type of management feedback is provided by weekly customer meetings that provide the customer the opportunity to discuss problems with the total ELD management team.

2.5 Plant Engineering

2.5.1 Organization

Plant Engineering consists of three groups (see exhibit 2.5.1):

1) Electrical
2) Mechanical
3) Architectural/Civil/Structural

2.5.2 Quality Assurance in Plant Engineering

2.5.2.1 General

Plant Engineering performs design, construction, installation, and maintenance primarily in the areas of conventional engineering. Quality assurance plans and policies in different groups are presented in Appendix D.1.

2.5.2.2 Design

Design work is carried out following approved SLAC and industry procedures and standards (listed in Appendix A.2). Most of these conventional design practices are well documented in existing manuals, standards and other literature. Unusual designs go through extensive initial reviews before the actual detailed design is started. The group leaders take the responsibility for all the designs, and designs must be reviewed and approved before any further steps are taken. Group leaders sign drawings, specifications, and procedures at design phase.

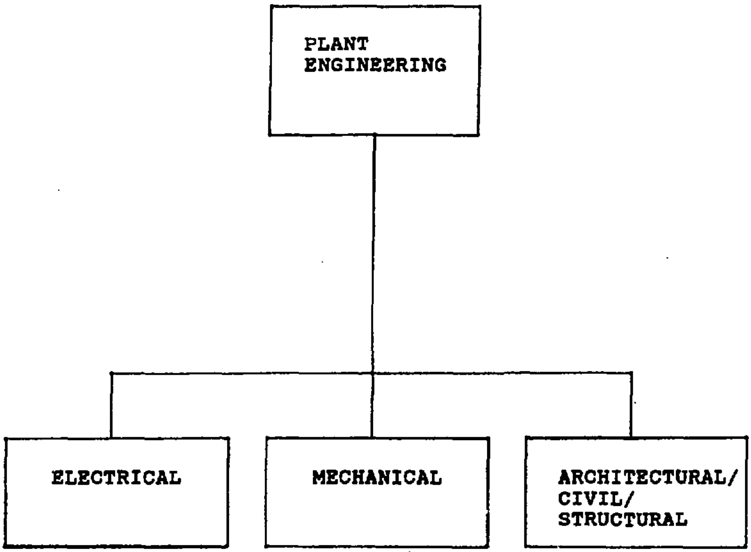
Documentation follows SLAC drafting rules and approved industry standards (Appendix A.2).

2.5.2.3 Incoming Material and Product Control

Incoming materials come either through the Purchasing Department or directly from selected vendors. Plant Engineering maintains an approved list of vendors that supply most of the standard industry items used in construction, installation, and maintenance.

A normal quality check for incoming materials and products consists of a visual inspection and a review of documentation. More extensive testing is performed if necessary according to the design requirements.

Exhibit 2.5.1


PLANT ENGINEERING
ELECTRICAL
MECHANICAL
ARCHITECTURAL/ CIVIL/ STRUCTURAL

2.5.2.4 Production and Operation

Fabrication/construction, installation, and maintenance are performed to existing standards and approved industry practices. The ultimate responsibility for the work performed in various groups always belongs to the responsible project engineer who must review and sign off all completed projects before transferring the responsibility to the customer.

The control of documents (blue prints) in the Laboratory is under Plant Engineering. Existing and approved prints are stored in a central document control facility, and retrieved and revised upon request. Other documentation within the department follows general engineering standards and practices.

2 5.2.5 Quality Assurance Information

Meetings between group leaders and workers are held frequently. The main tools in the area of quality information are sign off responsibilities, personal supervision and follow-up. Especially during construction engineers make frequent field inspections to check for compliance with drawings and specifications.

2.6 Accelerator Department

2.6.1 Organization

The Accelerator Department consists of six sections (see exhibit 2.6.1):

1) Storage Rings
2) Linac And Sources
3) Beam Delivery
4) Operations
5) Controls
6) Power Conversions

2.6.2 Quality Assurance in Accelerator Department

2.6.2.1 General

Sections 1, 2 and 3 are responsible for maintainability, operability and improvement modifications in their areas. Sections 4 and 5 are responsible for the operation of the entire accelerator complex, as well as maintenance, repair and improvement of hardware and software control and diagnostic systems. Quality assurance issues in software engineering are discussed in Appendix E.1. Section 6 is responsible for the power conversion systems. Design of new of hardware and software is performed in Sections 5 and 6. These designs are usually based on specifications provided by Sections 1-4.

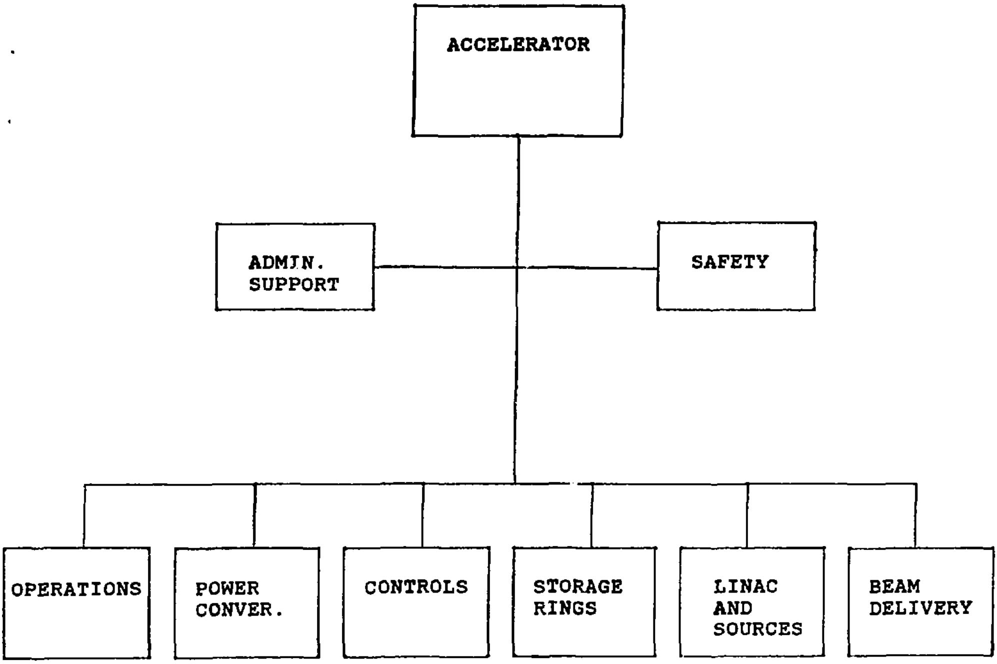
2.6.2.2 Design

Most of the design work in the Accelerator Department lies in developing the control and diagnostic systems (software and hardware), primarily in the Controls Section. Some design work also takes place in the Power Conversions Section. A list of "Things Pending for Operations Support" is kept and updated by the Controls Section including priorities assigned to various improvement proposals (see Appendix E.2). Solving operational problems normally initiates a preliminary conceptual design or modifications to existing systems.

New designs as well as existing control systems must conform to industry standards (e.g. IEEE, ANSI, GPIB). Designs are reviewed and tested before actual implementation.

Documentation is mainly in the form of computer data bases, manuals, and design reports (for example, hardware manual, drawings, technical notes, software coding manual).

Exhibit 2.6.1


ACCELERATOR
ADMIN.
SUPPORT
SAFETY
OPERATIONS
POWER
CONVER.
CONTROLS
STORAGE
RINGS
LINAC
AND
SOURCES
BEAM
DELIVERY

2.6.2.3 Incoming Material and Product Control

Some incoming materials and products are inspected, tested and accepted by the using sections (1-4). This is the case whenever items come through the Purchasing Department.

The Controls and Power Conversions Sections are involved in the design, installation, and maintenance functions. In this case, incoming materials are tested and reviewed by these groups to ensure proper operation and maintainability. Complete documentation is required to improve future repair and maintenance.

2.6.2.4 Production and Operation

There are few production functions in the Accelerator Department. Mainly, the department is responsible for operating the accelerator, including its various technical components, and for maintenance and improvement.

The Operations Section operates an extensive computerized accelerator control system with built-in procedures and different level checks. Individual components in the accelerator can be monitored and controlled, and the history of operation and malfunctions is recorded. Operations Section interacts closely with other sections, especially the Controls Section, in the development of control procedures and new techniques.

The Storage Ring, Linac And Sources, Beam Delivery, and Power Conversion Sections are responsible for operation of the technical systems of the accelerator. Area Managers are responsible for individual areas, and they act as an interface between different sections and other departments for coordinating, making downtime schedules, reporting problems, etc.). The response time when problems occur is an important measure of quality.

Accelerator Department documentation is in the form of computer software and databases. Other documentation include a priority list (things pending for operations support), weekly summary reports, and downtime schedules. Records are also kept for components including technical documentation (travelers, data sheets, etc.) that accompanies them from the production. Appendix E.2 shows examples of the documentation in the Accelerator Department.

2.6.2.5 Quality Assurance Information

One of the sources of quality assurance information in the Accelerator Department is the CATER (Computer-Aided Trouble and Error Reporting) problem entry system. This data base is accessible via the SLC control system as well as through conventional terminals. Both hardware and software problems from PEP, SPEAR, and SLC are entered in it, with details describing the component affected, the symptoms, and the urgency of repair. When a solution or repair is effected, a brief description of the remedy and the effort required is recorded, and finally the relevant supervisor closes out the problem when he is satisfied with the repair action taken. Various reports are available, either on-line or in hardcopy form, describing various subsets of the data-base, for example, a history of all unsolved urgent problems.

A second source of quality assurance information is the Laboratory Electronics Pool (LEP under the Electronics Services Group in the ELD) data base available on the central IBM computer system. This data base provides historical information (including repair actions) for hardware on a module-by-module basis.

2.7 Research

2.7.1 General

The entire Research Division and the Accelerator Theory and Special Projects Department are discussed here because of the similarities in the nature of their work. In both cases, the work is theoretical and experimental research, although in different fields.

2.7.2 Quality Assurance in Research

In research the main basis for quality assurance is the peer review process. This review is performed by experts inside the Laboratory and by the outside scientific community. Large projects are also reviewed by government officials and expert teams from outside the Laboratory.

In theoretical research, new methods are often tested on problems with proven alternate solutions, and then applied to new problems. The peer review process continues until the method is found satisfactory or rejected. In experimental research, the work is often carried out by multiple teams to confirm observations and critique any conclusions. Individuals and groups take responsibility and pride in their work, since in this kind of scientific community the reputation of a scientist is basically the same as the quality of his or her work. Normally, when design and manufacture is involved (experimental research), the original designer is personally responsible for the quality of the product, although fabrication may take place in other departments.

In research the documentation is mainly in the form of design and research reports and published papers. See for example the Mark II Publication Policies shown Appendix I.2c. Software documentation is discussed in more detail in Appendix E.1 "Quality Assurance in Software Engineering."

2.8 Purchasing

2.8.1 General

Purchasing activities in the Laboratory are always performed by the Purchasing Department. Various user groups request supplies and services, and departmental incoming material controls are discussed under each department in this manual. Here the main focus is on the Purchasing Department and the way the quality of purchased products and materials is assured for the Laboratory.

2.8.2 Quality Assurance in Purchasing Department

The Purchasing Department operates as an interface between users in the Laboratory and outside vendors. Purchasing orders items in three different categories:

1) From part numbers provided by users
2) Following specifications defined by users
3) Using formal technical specifications which are reviewed in Purchasing prior to procurement

In each case, final quality control is the responsibility of the user. In the last category, the order must be inspected and approved by the user, and a Material Acceptance Report (see Appendix G.1) must be completed and signed by the user before Purchasing can make the final payment to the vendor. When problems occur (defective items) payments are normally delayed or cancelled. When appropriate, warranties are obtained to assure normal operation for certain periods.

A purchase analysis, performed by the Purchasing Department, includes a competitive bidding process. Multiple suppliers are usually considered. Potential suppliers must meet quality requirements, and a vendor pre-rating system is in use to help in selecting the best suppliers.

Quality assurance requirements are included in contracts and orders when users feel they are appropriate. Normally, off-the-shelf products are covered by warranties. Users are responsible for keeping appropriate records (vendor performance rating, material traceability, etc). The final user is always responsible for defining quality requirements, quality levels, reliability requirements, and certification procedures.

Incoming materials and parts are reviewed (conformance to specifications) by the user. A Material Acceptance Report is used when items are ordered to formal technical specifications. Users sign off orders only if they are satisfactory. If incoming materials and parts are unsatisfactory they are returned to the vendor and payments are cancelled.

2.9 Experimental Facilities Department

2.9.1 Organization

Experimental Facilities Department (EFD) consists of five sections (see exhibit 2.9.1):

1) Mechanical Installation & Management
2) Liquid Hydrogen Targets
3) Low Temperature Materials Research
4) Cryogenics Operations
5) Cryogenics Engineering

2.9.2 Quality Assurance in EFD

2.9.2.1 General

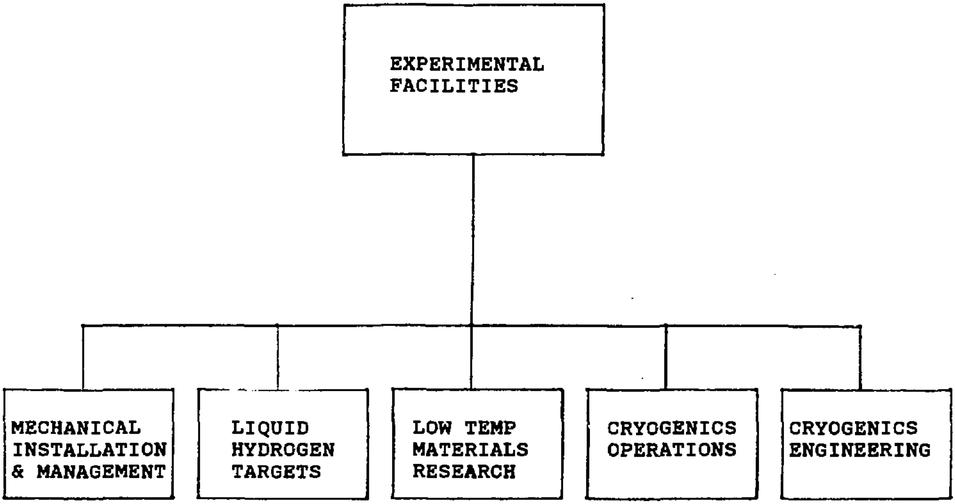
EFD is responsible for the physics and engineering support, installation support, and operation and maintenance of experimental facilities in the fixed target area and the SPEAR, PEP, and SLC interaction areas. Some of the activities include particle beam transport system design, test beam scheduling and operation, detector instrument development, design of new experimental facilities, design and operation of cryogenic systems, and long range scheduling. EFD provides general purpose equipment such as hydrogen targets, analyzing magnets, and shielding, and arranges for the use of other equipment such as power supplies. In addition to this, EFD operates the Central Helium Facility and is responsible for the distribution of liquid nitrogen as well as liquid and gaseous helium on the site.

EFD frequently uses engineering and other resources from outside the department. Also, EFD engineers and physicists are often assigned to work on projects which are managed by other groups. A lot of the work is one-of-a-kind in nature, and requires extensive R&D and testing. In many cases, the final responsibility for quality assurance belongs to the customer.

2.9.2.2 Design

In the Liquid Hydrogen Targets, group designs are based on the specifications from physicists. The design work is carried out according to industry standards whenever applicable, and documented in step-by-step written procedures (see Appendix H.1). Safety reviews are performed by the Hazardous Experimental Equipment Committee (HEEC), and the normal goal is a fail-safe design. This design process includes much testing and prototyping.

Exhibit 2.9.1


EXPERIMENTAL FACILITIES
MECHANICAL INSTALLATION & MANAGEMENT
LIQUID HYDROGEN TARGETS
LOW TEMP MATERIALS RESEARCH
CRYOGENICS OPERATIONS
CRYOGENICS ENGINEERING

In the cryogenics groups standards, often MIL-specs, are used whenever possible. Engineers are responsible for the work, and extensive R&D, prototyping and testing are performed whenever new designs are implemented. Special attention is paid to the safety issues in designs.

The Mechanical Installation & Management group does not usually perform detailed design work. As appropriate, their plans and policies are reviewed by the HEEC and the Earthquake Safety Committee. Appendix H.1 shows examples of the HEEC and Earthquake Safety Committee reviews.

2.9.2.3 Incoming Material and Product Control

Incoming material control follows the procedures of the Purchasing Department (see section 2.8, Purchasing). In some cases when work is performed outside the Laboratory, the suppliers are monitored carefully. Normally, test procedures are required and checked and thorough test documentation is required. Most work performed outside the Laboratory must use this formal procurement process.

2.9.2.4 Production and Operation

In many cases production consists of single items or small quantities. Prototyping and testing serve as a quality assurance tool in most of the design and production work in the department. Normally, designers and engineers are involved in their projects until the designs are built and installed. The need for formal procedures and policies is determined based on the requirements and complexity of each individual project.

In the Mechanical Installation & Management group various areas are assigned to different coordinators, who are responsible for the mechanical installation and coordination in their areas.

Examples of standard documentation is shown in Appendix H.1. Some of this material applies to the Instrumentation and Electrical Installation & Coordination Group which is currently under the Electronics Department.

2.9.2.5 Quality Assurance Information

Quality assurance information is mainly in the form of design reports, manuals, and papers. Some of the documentation in the EFD is shown in Appendix H.1.

Problem reporting is usually handled informally in meetings. Meetings also serve as an important information tool within the department.

2.10 Special Projects

2.10.1 The SLC Large Detector (SLD)

2.10.1.1 General

The SLD group is engaged in the development and construction of a new particle detection device for use in the SLC. This device, the SLC Large Detector, will be the second at SLC, and will be optimized for the unique physics opportunities available there.

The organization chart of the SLD is presented in exhibit 2.10.1.1. All these groups extensively use other resources and services from various departments at SLAC.

A Quality Assurance Coordinator is included in the organization to implement guidelines that assist engineers and managers in the areas of concern.

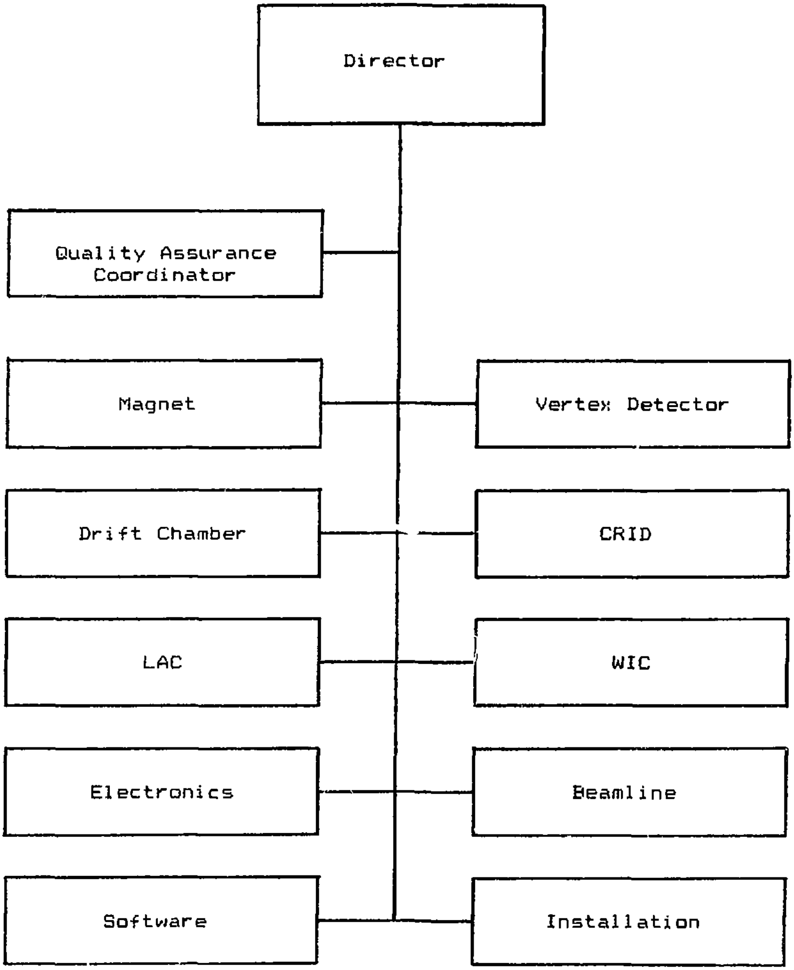
2.10.1.2 Quality Assurance in the SLD Project

Currently, the SLD project is approaching the installation and testing stage. Most new design and procurement activities are completed. The main function of quality assurance is to assure that the items received conform to specifications, that installation is carried out according to specifications and procedures, and that system performance be proven by various test procedures.

The quality assurance program of SLD has been implemented by an experienced SLAC engineer/manager who has provided procurement packages, reviewed development work, construction procedures, and calibration efforts to support project needs. He has served as a coordinator between different groups, assuring the compatibility and functionality of the systems.

General Quality Control/Quality Assurance instructions, written by various supervisors and the quality assurance coordinator, are in use covering major stages including design, procurement, fabrication, installation, and operation and maintenance (Appendix I.1a). SLD group leaders are responsible for following these guidelines. The QA coordinator monitors the use of these rules by continuously reviewing procedures and specifications, and makes suggestions for improvements.

Exhibit 2.10.1.1 SLD Organization



The documentation process of the SLD project is extensive. The QA coordinator has maintained a list of technical specification written by many SLAC groups to assure the consistency of the documentation process. The table of contents of this list is shown in Appendix I.1b. The QA coordinator has also maintained a complete file of specifications, procedures, and other documentation on a continuous basis. Some of the standard documentation is shown in Appendix I.1c.

2.10.2 Mark II

2.10.2.1 General

The Mark II Project involves upgrading the Mark II to become the first detector for the SLAC Linear Collider (SLC). This upgrade is built on a large amount of existing and well proven hardware and software as well as a great deal of experience at SPEAR and PEP.

Issues dealing with personnel, management, funding, schedule, and organization (Mark II Articles of Organization) are discussed in Appendices I.2a and I.2b.

2.10.2.2 Quality Assurance in the Mark II Project

One of the main quality assurance actions in this project has been the selection of highly qualified scientists. The nature of the project has allowed the project leaders to choose technically strong and highly motivated scientists and engineers. This has contributed to the cohesiveness and motivation of the entire group.

The guidelines for the theoretical work in the project are described in Mark II Publication Policies Appendix I.2c. Although the peer review process is the main quality assurance tool, these policies state the expectations and standard rules for any publications in the project.

Initial designs are all reviewed by the project leader and project engineer, who is responsible for the total assembly of the detector. The subsystem leaders and engineers are responsible for the work in their areas. Detailed design is carried out under the supervision of these subsystem groups.

The construction of the detector itself has relied heavily on prototyping and component testing. For example, a reduced scale prototype of the detector was built and tested, and the test results were used to trace problem areas and needs for design modifications. All incoming items and systems, both from inside and outside suppliers, have gone through extensive testing to assure their conformance to requirements. Most of the mechanical systems have been built inside the Laboratory, while most of the electronics, except for some one-of-a-kind items, have come from outside vendors. In some cases, the quality of the outside suppliers has been followed by frequent inspections of their production techniques and facilities.

2.10.3 Mark III

2.10.3.1 General

This is a summary of some of the quality assurance procedures that are used by the Mark III physics collaboration. The main topic has been the project upgrade to design and build a vertex detector, namely a small high pressure drift chamber. This has as its goal high resolution as close as possible to the origin of the events.

2.10.3.2 Quality Assurance in the Mark III Project

A. Vertex detector

The design stage of the inner vertex detector went through two different levels. At the concept level control was confined to weekly meetings where ideas were exchanged, further calculations made and reported on. At this stage, control was confined to whether suggestions were practical, affordable and desirable.

At the second level, design concepts were already decided and the goal was to determine how to build the design within an existing framework, and still accomplish the design goals. Quality was maintained by at least two and usually three independent drawing reviews.

In the next stage of the project, parts were coming in and quality control ascertained whether or not the parts conformed to the specifications. Certain items had to pass established criteria of acceptability, criteria that had been written into the purchase orders. In particular, the beam pipe had elaborate tests that had to be witnessed before items were accepted. The other item that required very detailed quality control was the hole location in the two end plates. This control was done during construction by checking positions with a numerically controlled mill where the parts were made. At the conclusion, hole positions were measured at the control shop at SLAC.

In the building and testing of the detector, there was an extensive quality procedure for each layer. One layer had to pass the quality requirements before the next layer could be built over it. The "pass" criteria involved an extensive sealing of the detector and pressure tests with electronics testing of each channel. This data was fed into an on line computer that gathered suitable cosmic ray events to test the built detector. There was thus recorded and stored data on each channel.

B. Gas supplies

When gas is delivered, it must be certified by the company with amounts of impurities listed. A separate analysis is performed on site that compares the new gas with standard mixes. A detailed measure of the mix is provided and this measure is recorded in a log book. Using an oxygen analyzer, the amount of oxygen in the mix is also determined. Since the amount of this electronegative gas that is allowed is very small (one part per million), this test requires great control and care. This amount is also logged and the suitability of the gas is determined.

Examples of QA procedures in the Mark III project are shown in Appendix I.3a.

2.10.4 Polarization

2.10.4.1 General

The Polarization Project involves the design and fabrication of the Stanford Linear Collider (SLC) longitudinal polarization production and measurement facility. This project is divided into five subgroups:

1) Polarized Electron Source
2) Spin Rotating Solenoids
3) Spin Dynamics
4) Polarimetry
5) Data Acquisitions

2.10.4.2 Quality Assurance in the Polarization Project

The following discussion describes a typical process flow from the design stage to the installation and operation stages. Most of the systems follow this type of process. A typical design proposal is included in Appendix I.4.

Initial designs are normally carried out within the Laboratory, usually in cooperation with scientists from various experimental groups, EFD and other design groups. All the design work must follow SLAC and industry standards, and conform to widely used and approved engineering practices. Initial designs are thoroughly reviewed and inspected within the Polarization group before proceeding to the detailed design stage. Detailed designs often are done within the Polarization group, but in some cases are performed by other groups (Electronics Department, Mechanical Engineering, etc). In the latter case, designs are inspected and reviewed by the Polarization group before a final approval. Compatibility between new designs and existing SLC systems is a requirement during the design stage to improve operability and maintainability.

Incoming material control involves the systems and parts that are made by outside vendors or by in house production. In the first case, a list of potential vendors is carefully planned with special attention given to the quality assurance of the vendors, and multiple bids are considered. Once the contract has been awarded, a continuous follow-up of vendor quality assurance is maintained (factory visits, reviews, inspections, etc). For in house production, a prototype is often built, reviewed and tested before producing the rest of the items. All received parts and systems go through an extensive inspection and acceptance testing process before final approval and installation.

All the installed systems go through thorough testing and commissioning processes before final approval. A detailed documentation system has been developed to cover all the systems and parts through the different stages to assure a maximum compatibility and high level of quality.

2.10.5 Time Projection Chamber (TPC)

2.10.5.1 General

The Time Projection Chamber (TPC) project is a collaboration between SLAC, UC Berkeley and other University of California campuses. The main effort has been the use of the TPC detector, which is a gas filled cylindrical detector providing 3-D images of tracks from charged particles and ionization energy loss information, at the upgraded PEP. The work during the last few years has included the design and construction of a new vertex chamber and the development of new related software.

2.10.5.2 Quality Assurance in the TPC Project

The TPC project, like many other projects in the Research Division, is a group effort. The desire of individual scientists to achieve the proposed design goals and their personal reputation are the main building blocks in assuring quality. The entire project has been a form of a quality circle approach, although a formal organization chart was formed to define the key persons in the project. The following paragraphs summarize some of the procedures that have been implemented during the design, incoming material control, and production and operation stages.

The designs have been reviewed, mainly informally, in the weekly meetings of the collaboration. In some cases, when problems have occurred or designs have required outside expertise, more formal reviews have been requested. This was the case in some of the electronics designs that were reviewed by Berkeley engineers. Most of the time, design reviews have relied on the technical experience in the group.

Incoming materials and parts are normally reviewed by the responsible technician in the group. This review includes visual check and samples of measurements (tolerances and other physical dimensions). Most of the part manufacturing has been done by outside vendors chosen based on thorough conversations and previous experience with a number of vendors. In many cases, continuous vendor surveillance has been maintained during the production.

The mechanical assembly of the detector has used the same informal review process as the design. Statistical sampling techniques have been used when determining tolerance buildup in final assemblies. There has been a full disclosure of changes made during the assembly as well as during the operation of the detector including the software development in the project. Possible consequences have been considered and the changes well documented.

2.11 Stanford Synchrotron Radiation Laboratory (SSRL)

2.11.1 Organization

The Stanford Linear Accelerator Center (SLAC) and the Stanford Synchrotron Radiation Laboratory (SSRL) operate under separate contracts with DOE. However, they are located on the same site and SSRL uses SLAC facilities and services.

A simplified organization chart of the Stanford Synchrotron Radiation Laboratory (SSRL) is presented in exhibit 2.11.1.

2.11.2 Quality Assurance in SSRL

2.11.2.1 General

The focus here is on the design, engineering, and production of the hardware in SSRL. This operation is relatively small and there is no formal quality assurance plan. In this type of small scale operation, often making one-of-a-kind products, individuals are personally involved from the early design stages to the final installation.

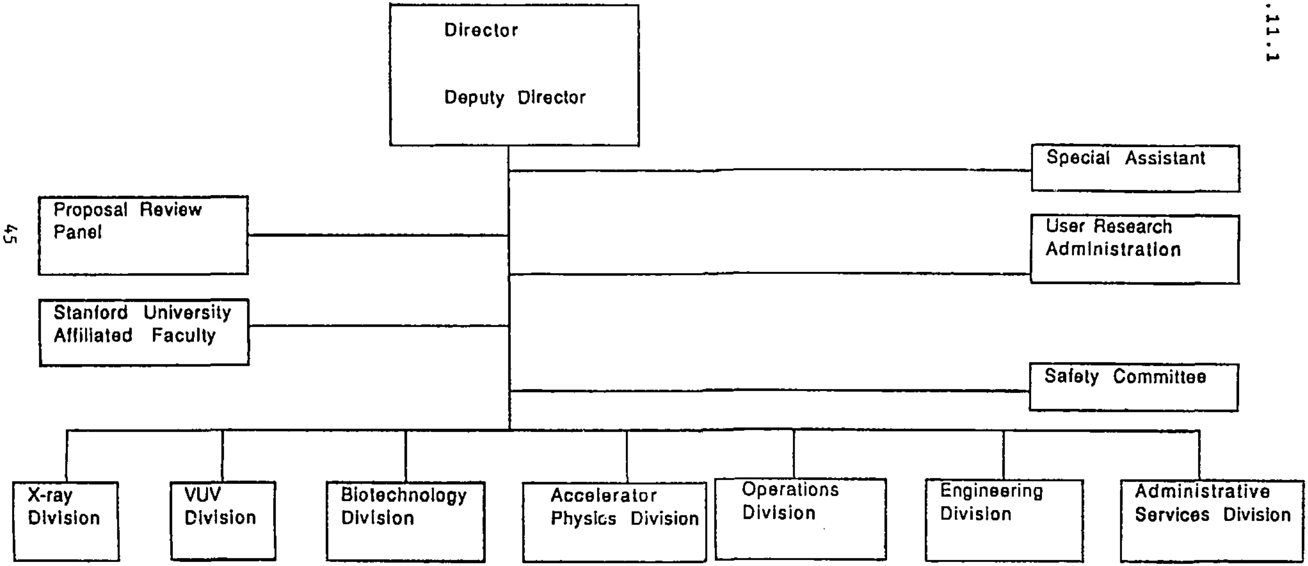
2.11.2.2 Design

Practically all new design work is performed within SSRL's own design groups. The project engineers are personally responsible for the design in their groups, and internal design reviews are performed routinely. These reviews are mostly informal meetings, and include both scientific and operational aspects of designs as well as the quality of drawings. Normally, individual designers are involved in their projects until the design work is completed, and have input during production and operation stages. Standards and good engineering practices are in use, and designs are usually made compatible with existing SLAC systems. For example, all the vacuum systems designed by SSRL are reviewed by the SLAC Vacuum Group which is responsible for the production, installation, and operation of all the vacuum systems on the site.

2.11.2.3 Incoming Material and Product Control

SSRL uses SLAC services in all of its purchasing, shipping and receiving activities. Therefore, the procedures described in section 2.8 (Purchasing) apply for SSRL. Also, most SSRL materials are obtained from the SLAC General Stores and Metal Stores.

Exhibit 2.11.1



Practically all parts production is done externally, either using SLAC facilities or outside vendors. For example, all the cleaning of vacuum components takes place in the SLAC cleaning and plating shop. A list of vendors is maintained based mainly on the past experience. A competitive bidding process is performed routinely.

Incoming parts are checked for quality before final assembly. Normally, project coordinators personally check the parts visually and also measure critical dimensions. In low volume, one-of-a-kind production this method is adequate in assuring the quality of incoming items. Substandard and defective items are returned to the responsible vendors, and the vendor list updated accordingly.

2.11.2.4 Production and Operation

Most production takes place outside of SSRL. SSRL has a small machine shop that is used only for minor prototyping and modification work. Some final assembly, including some welding work, is performed within the Laboratory. The welders and their equipment are provided by SLAC. Normally, the project engineer is responsible for quality assurance, including quality checks and reviews of parts and systems, until the systems are installed.

2.11.2.5 Quality Assurance Information

Since production is usually low volume, the information flow is handled mainly informally. Meetings are held frequently, and managers as well as workers are usually personally involved during different stages of the project. For example, designers are routinely involved in the actual manufacturing, assembly, and installation of their designs. This is one of the main factors in worker motivation.

3. OTHER QUALITY ASSURANCE ISSUES

3.1 Unusual Occurrence Reporting System

3.1.1 General

This section describes a policy and actions to be taken when there is an incident classified as an unusual occurrence.

3.1.2 Definition

An Unusual Occurrence is any unusual or unplanned event having programmatic significance such that it adversely affects or potentially affects the performance, reliability, or safety of equipment, systems, buildings, utilities, services, and related activities at the Stanford Linear Accelerator Center.

3.1.3 Policy and Objective

In the case of an unusual occurrence, a formal, standard report shall be completed promptly to inform management, and corrective action shall be taken to prevent or minimize the probability of recurrence. The objective is to keep management aware of significant technical and operational problems.

3.1.4 Responsibilities

The responsible line manager and the department head must report any unusual occurrence to the Laboratory quality assurance representative, and to the head of the Technical Division.

3.1.5 Procedures

Each unusual occurrence shall be reported in writing on a standard form. This report shall be written so that it can be readily understood by reviewers who may not be familiar with the circumstances, facilities, or activities involved.

Each report shall be completed and signed by management of the originating department to assure that:

1. Each unusual occurrence is clearly, completely, and accurately described

2. Explanations of causes, immediate actions taken, and effects on the program or the facility are included

3. Corrective actions taken are sufficient

3.1.6 Reporting Criteria

The following shall be considered as the basis for reporting an unplanned event as an unusual occurrence, and department heads should use their own judgement in deciding whether an event matches this criteria.

1. Any violation of approved technical specifications or operating safety requirements or other safety limits

2. An unplanned event in any program which results in a significant program delay.

3. A deficiency such that a system or component vital to program performance does not conform to stated criteria and cannot perform its intended function.

4. A deficiency in construction, manufacturing, operation, testing, maintenance, modification, or damage to a structure, system, component, or facility which to redesign or repair or otherwise correct will result in a significant program delay or cost.

5. An unplanned event during field, Laboratory, or facility testing which results in the loss of essential test data or will result in a significant program delay to evaluate, redesign, retest, or correct.

3.2 SLAC Committees

3.2.1 General

The following summarizes the main functions of different committees in the Laboratory. While these committees consider safety and other administrative issues, they often conduct complete technical reviews that are very useful in assuring the quality of Laboratory products.

3.2.2 Technical Safety Committees

Earthquake Committee

Reviews and evaluates all areas of the Laboratory for compliance with applicable seismic safety standards.

Electrical Safety Committee

Identifies and evaluates electrical hazards and risks of electrical faults on major equipment and recommends to management methods for eliminating or reducing exposures and risks.

Hazardous Experimental Equipment Committee (HEEC)

Establishes design criteria and test procedures for equipment; reviews operating procedures and qualifications of operating personnel; submits written reports and recommendations (see Appendix K.2a).

Mechanical Engineering Safety Inspection (MESI)

Provides written approvals of design, fabrication, pressure test, and operation stages for pressure or vacuum vessels. While the primary responsibility for safety remains with the cognizant line management, no work may proceed at each sequential stage from design to operation of a vessel without prior written approval of MESI (see Appendix K.2b).

Non-Ionizing Radiation Committee

Reviews and evaluates electromagnetic frequency generators, lasers, and recommended controls for safe operation.

Radiation Safety Committee

Acts as a review group on radiation matters, including shielding design reviews for new accelerators and detectors and for modifications to accelerators and detectors.

3.2.3 Other Safety Committees

Best Management Practices Committee

Reviews and evaluates practices of the Laboratory for compliance with best management practices for water quality control as specified in the National Pollution Discharge Elimination Permit (NPDES).

Operating Safety Committee

Studies accident and injury experience; spotlights problems; proposes solutions; advises Safety Policy Committee.

Safety Overview Committee

Reviews new major projects, experiments or major modifications to existing facilities. Safety approval of this Committee is required before major new projects, experiments or major modifications to existing facilities can proceed.

Safety Policy Committee

Determines SLAC safety policy and provides the means through which the safety effort can be monitored.

3.2.4 Other Committees

Experimental Program Advisory Committee (EPAC)

Advises the Director of SLAC in establishing the program commitments for the accelerator and experimental facilities.

Nuclear Program Advisory Committee (NPAC)

Advises the SLAC Research Division Associate Director in establishing program commitments for the Nuclear Physics program at SLAC (NPAS).

Scientific Policy Committee (SPC)

Represents the interests of SLAC's user community by reviewing SLAC's program and policies, its relationship with users, and the like; invites users and prospective users of the SLAC facility to address any problems or suggestions they may have to any of the members of the SPC. Advises the President of Stanford University.

3.3 SLAC Standards

3.3.1 General

Approved industry standards (ANSI, ASME, etc.) are widely used in the Laboratory. There is a need for continuous coordination and revision of changing standards. The following summarizes efforts in the area of standards development in the Laboratory.

3.3.2 SLAC Drafting Standards Rewrite Group

The SLAC Drafting Standards Rewrite Group is rewriting general drafting standards in the Laboratory, and defining and coordinating related requirements and general practices. The Document Control under the Plant Engineering Department stores a large number of prints, and thus the same general drafting standards must be applied in all areas of the Laboratory. This group has revised and is currently working on a number of drafting standards listed in Appendix K.3a.

3.3.3 Other Standards Development

The Vacuum Group has published a manual "Technical Specification for Vacuum Systems" (SLAC-TN-86-6) to serve two primary purposes:

1. To insure the cleanliness of and vacuum integrity of all SLAC vacuum systems
2. To assist personnel involved with SLAC vacuum systems in choosing and designing components that are compatible with the existing systems and which, as determined through testing and evaluation, meet the quality and reliability of SLAC vacuum standards.

The purpose of the Electronics Department Documentation Task Team is to solve problems together with the Accelerator Department in the existing documentation system, mainly in the area of drawings and general definitions.