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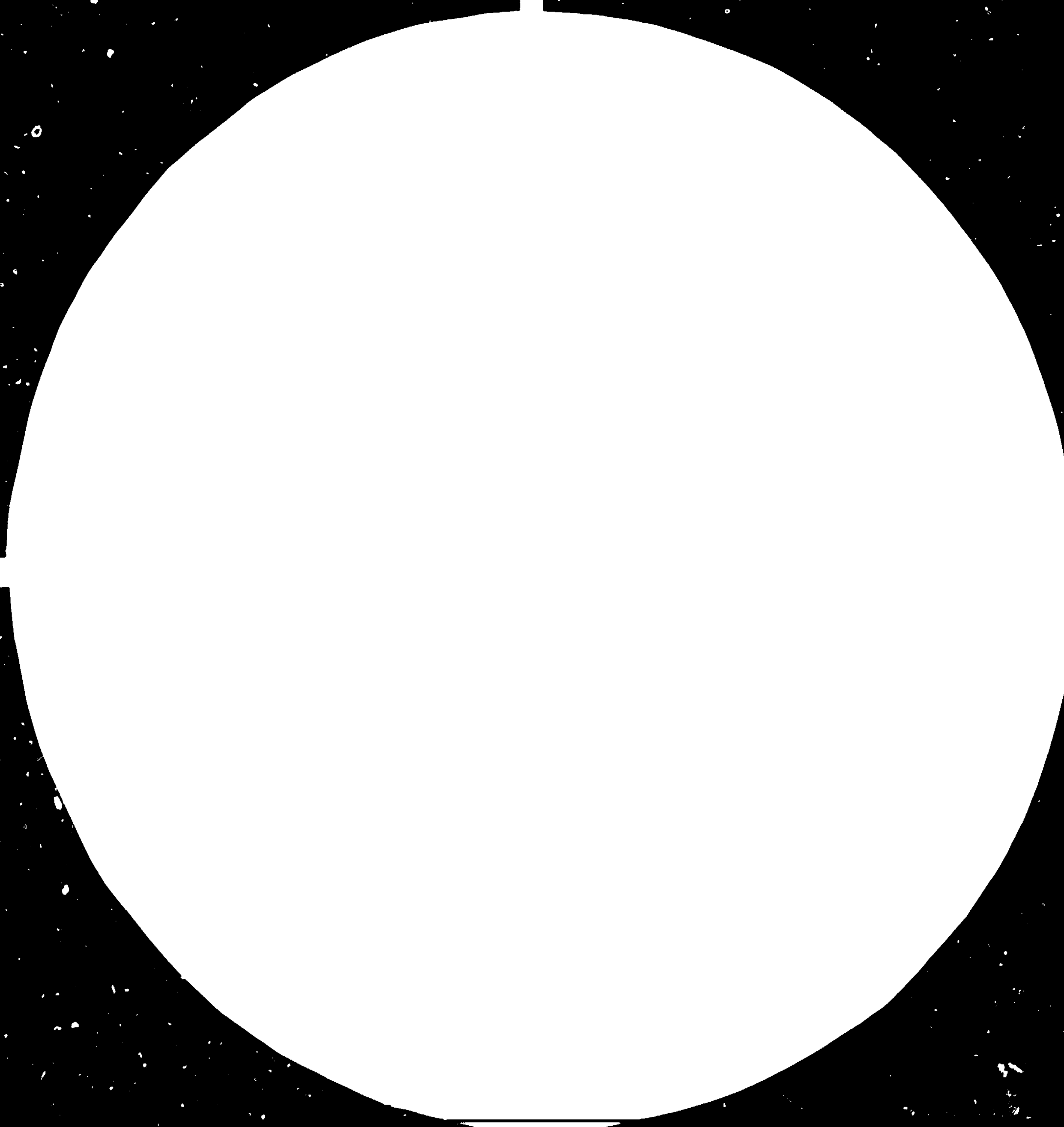

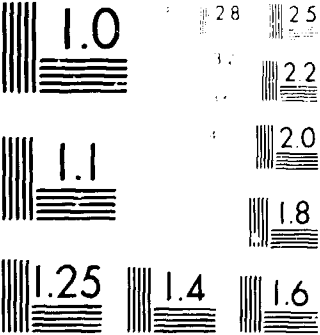

MICROCOPY RESOLUTION TEST CHART

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12904

Distr.
LIMITED

UNIDO/IO.557
7 September 1983

English

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Seminar on Subject of Certification
and Evaluation of Electronic Components

Guangzhou, People's Republic of China
27 May to 16 June 1983

QUALIFICATION AND SURVEILLANCE LABORATORY FOR CONSUMER ELECTRONIC PRODUCTS *

DP/CPR/81/028

prepared by

Mr. Abe M. Okun
UNIDO Consultant

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TABLE OF CONTENTS

	Page
Summary	3
Seminar Agenda and Subjects Covered	5
General Observations and Discussions with CEPREI Management	7
Recommendations	8
List of Attendees	9
Overview of Testing and Evaluation (Notes Used in Seminar Days 1 through 21)	10
Typical Forms Used to Record Testing	40
Electronic Component Testing - Some Definitions by Alan Albert	55
The Joys of Component Screening by Alan Albert	60
Overview Plates Used in Seminar	68-90

SUMMARY

A Seminar on the subject of "Certification and Evaluation of Electronic Component Parts" was given at the China Electronic Product Reliability and Environmental Testing Research Institute (CEPREI) in Guangzhou, People's Republic of China, from May 27 through June 16, 1983. Much of the subject matter of the Seminar consisted of answering nineteen (19) questions submitted to me by CEPREI Management one month preceeding the Seminar.

The format of the Seminar consisted of a lecture of from two and one-half (2½) to three (3) hours of lecture in the morning session with a question and answer period lasting from three (3) to four (4) hours in the afternoon. The types of questions asked and the number of questions indicated a great interest and significant knowledge of the subject matter.

A number of MIL type specifications, standards and handbooks on electronic components, reliability testing and quality systems were brought with me under approval and license from the U. S. State Department, license number 193319.

There were forty-two (42) regular students that attended the Seminar. In addition to the regular students, other students (observers) attended a number of special lectures covering special subjects of interest. (A list of the regular students is attached as Appendix A.)

From the questions asked, it was evident that representatives from many different testing areas were present and very active in the Seminar. Questions on testing passive components (capacitors and resistors), active components (diodes, transistors and integrated circuits), and electro-mechanical components (switches, connectors and relays) were asked and discussed.

In a few instances, I did not have answers to the questions asked, but promised to research the question and supply answers in the near future. These questions concerned specialized equipment available for certain tests on electro-mechanical components such as:

a. What equipment is used in testing connectors for mating and unmating life tests?

b. What equipment is available for testing relays for endurance testing, especially to detect contact bounce and contact miss?

I would like to take the opportunity to acknowledge the friendliness and full cooperation received from Mr. Lu Chung-yu, Director of CEPREI, Madam Wang Xiurou, Deputy Director of CEPREI, Mr. Ma Huaizu, Chief Engineer of CEPREI and Mr. Yi Zhiyun, Program Manager of the UNIDO Project at CEPREI.

I also wish to thank Mr. Li Mengwei, Director of Quality Control Department of the Ministry of Electronics Industry and Madam Ye Lansu, Department of Foreign Affairs of the Ministry of Electronics Industry.

Special thanks for the efforts and cooperation of the translators, Mr. Chiu Tsu-tung, Mr. Jong Ming and Mr. Jiang Yong for all of their assistance in making the Seminar a success.

SEMINAR AGENDA and SUBJECTS COVERED *

Day	Subject
1 & 2	Overview on Testing and Evaluation
3	Purpose and Function of Quality Certification
4	Origin and Development of Quality Certification
5	Requirements and Methods of Management of the Standards and Specifications Used in Quality Certification
6	Briefing on Quality Certification of Electronic Components in the U. S. A.
7	Briefing on the Application by the U. S. Certification Organization for Membership in the ICC (Inspectorate Coordinating Committee) of the IECQ (International Electrotechnical Commission Quality System) and its Approval by ICC/IEQC.
8	The Requirements of NAI (National Authorized Institution), NSI (National Standards Institute) and National Calibration Institute - taking the U. L. (Underwriters Laboratories) as an example. What are the requirements of ANSI (American National Standards Institute)?
9	What are the Procedures and Methods Used in Giving Approval to a Component (Product)?
10	What are the Procedures and Methods Used After Certification is Granted?
11	What are the Procedures of Appeal against the Conclusion Given to a Certified Product?
12	The Application, the Procedure of Management and the Method of Surveillance Used for Quality Certificates and Quality Mark of Conformity
13	What are the Differences Between the Existing Marking Systems Used in Various Countries and that of the Quality Certification System?
14	The Future Development of the Evaluation Techniques of Components
15	Besides using the "Component Hours Method", are there any other methods used in Quality Evaluation of Components?

Day	Subject
16	What are the Methods Used in the U. S. A. for the Evaluation of the Failure Rates of Components?
17	Briefing on the Reliability Evaluation Methods of Semiconductor Devices in the U. S. A.
18	How Shall We Sample and Evaluate Switches, Connectors, Potentiometers and Temperature Sensitive Components?
19	A. What are the Key Points in The Reliability Evaluation Techniques for LSI?
	B. What are the Key Measures Used and their Characteristic Features?
20	Briefing on the "Climatic Test Sequence" of Different Components in the IEC Standards
21	What are the Test Records and Test Report Formats Used by United States Laboratories for Evaluation Tests of Components?

* A complete set of notes and slides used are included in Appendix B.

Note: A copy of the complete set of notes was supplied to each regular student attending the Seminar.

GENERAL OBSERVATIONS and DISCUSSIONS with CEPREI MANAGEMENT

This trip (my third trip to China) consisted of a full four weeks - meeting with the Ministry of Electronics Industry and with Mr. A. Sissingh in Beijing on May 24th and 25th, leaving for Guangzhou on May 26th and meeting with the Management of CEPREI on May 27th, 28th and 29th (Friday, Saturday and Sunday). The Seminar began on May 30th (Monday) and continued through June 16, 1983.

During my meeting with Mr. A. Sissingh, I was asked to complete the Project Evaluation Report, Part I, Part II and Part III. This was accomplished and submitted to Mr. Sissingh during a Project Meeting on June 17, 1983 at which CEPREI Management, UNIDO Representatives, Ministry of Electronics Industry Representatives and myself, as CTA, participated.

I am impressed with the progress made by CEPREI in fulfilling the outputs of Project No. DP/CPR/81/028/C/01/37. As mentioned in the Performance Report, additional assistance by UNIDO and myself as CTA may be required to maintain the progress and complete this program on schedule.

My discussions with CEPREI Management regarding the usefulness of the Barnes Infra Red Scanning Microscope was fruitful. They agreed to delete this equipment from the proposed list of equipment. Other changes were made as discussed at the meeting on June 17, 1983 at CEPREI and included in the Report of the Meeting by Mr. A. Sissingh.

The Phillips SEM (Scanning Electron Microscope) with the Edax and Redax options is in operation, but requires some minor adjustments which were in progress of being accomplished by Phillips represenatives.

Air Conditioners have been installed in critical areas and recording temperature and humidity instruments are being used in these critical areas.

The major weakness in the Project lies in establishing the Fellowships as required in the program. Although this was anticipated, more time is required to establish the correct Fellowships that will be most productive for CEPREI. A Fellowship at a well-recognized Failure Analysis Laboratory and a Calibration Laboratory are yet to be finalized.

Recommendations:

A proposal to establish CEPREI as the service, maintenance and calibration organization for new technology equipment being procured and to be procured was made. CEPREI is in basic agreement and is studying this proposal with the Ministry of Electronics Industry. The proposal includes a recommendation for the Ministry of Electronics Industry to establish a buying office for electronic equipment in the U. S. A. If this proposal is accepted and implemented, additional fellowships at equipment manufacturers' facilities to study the maintenance, service and repair of the various equipment could be arranged.

Some new equipment was also recommended to CEPREI for the Qualification and Surveillance Laboratory for Consumer Electronic Products.

THE LIST OF THE NAMES OF STUDENTS

1. Jiang Jinfu	江擎孚	13. Zhang Xiangfa	张祥发
2. Yie Yuqing	叶玉青	14. Feng Yunxiu(fem.)	冯云秀
3. Huang Bingqi	黄秉琪	15. Chen Hui(fem.)	陈 辉
4. Pen Lieping	屈列平	16. Han Changying(fem.)	韩常英
5. Chen Wei	陈 伟	17. Wang Guangbin	王光斌
6. Huang Xinquan	黄欣泉	18. Yu Minghai	俞明海
7. Qiu Peihua	邱培华	19. Shen Guoliang	沈国良
8. Zhai Yuqin	翟玉庆	20. Jie Yinliang	揭英亮
9. Li Xiangdong	李向东	21. Lin Jun	林 军
10.Xu Weiwen	许伟文	22. Wu Qiongling	巫琼苓
11.Yu Liang	虞 亮	23. Bian Naipeng	边乃鹏
12.Dai Bingquan	戴炳泉	24. Yu Hanglin	禹航林

• The 24 students listed above are from CEPREI and participating in the Seminar as regular students. The other participants are as follows:

水之一 1. Shui Zhiyi (Shandong Provincial Electronic Product Testing Station)
喻恩源 2. Yu Enyan (Hubei Provincial Electronic Product Testing Station)
曹富大 3. Cao Fuda (Shanghai Municipal Electronic Product Testing Station)
潘国明 4. Pan Guoming (Beijing Municipal Electronic Component Testing Station)
何文翰 5. He Wenhan (Beijing Electron Tube Manufacturer)
尹清波 6. Yan Jingbo (Jiangnan Radio Equipment Factory)
杨琴秀 7. Yang Qinxiu (Huafeng Radio Equipment Factory)
张福祖 8. Zhang Fuzu (Jiangsu Provincial Electronic Product Testing Station)
徐金虎 9. Xu Jinghu (Jiangxi Provincial Electronic Product Testing Station)
王明之 10.Wang Mingzhi(Zhejiang Provincial Electronic Product Testing Station)
何镇乾 11.He Zhengquan(Jilin Provincial Electronic Product Testing Station)
朴风云 12.Piao Fengyun(Liaoning Provincial Electronic Product Testing Station)
苏德清 13.Su Deqing (NSO)
韩游海 14.Han Youhai (NSO)
徐小田 15.Xu Xiaotian (MEI)
张兆祥 16.Zhang Zhaoxiang (MEI)
徐惠琴 17.Xu Huiqin (MEI)
邓钻卿 18.Deng Zuanqing (Electronic Devices Manufacturer, Guangdong Province)

• The names of female students are underlined.

Day 1 and 2

OVERVIEW of TESTING and EVALUATION

(Notes Used in Seminar Days 1 through 21)

TESTING ACCOMPLISHED FOR A PURPOSE

A. Types of Tests
  1. Engineering Tests
    a. Step/Stress
    b. Thermal Analysis
    c. Endurance (Life) Tests - Sometimes test to failure
    d. Environmental Tests
    e. Characterization Tests (See #3 below)

  2. Qualification Tests
    a. To prove the design
    b. To determine capability of meeting specifications

  3. Characterization Test - Used by components users
    a. To determine that the same component from different manufacturers will operate as required in complex circuitry.

  4. Inspection Tests
    a. Made by Component Manufacturers to determine that lots produced meet specifications.
      1. Some tests are made 100%
      2. Some are conducted on samples
      3. Environmental tests conducted on lots periodically
      4. In some special instances, prepackaging tests are conducted.

  5, Incoming Inspection Tests
    a. Depends on product
      1. Thoroughness of tests
      2. Number of tests
      3. 100% or sample
      4. Destructive or non-destructive
      5. Sampling plan

Day 1 and 2

6. Burn-In tests - Screening - for elimination of early failures
    a. Static Burn-In
    b. Dynamic Burn-In
        1. Number of hours
        2. Temperature
        3. Voltage applied - operating (dynamics)

7. Reliability Tests
    a. Usually accomplished by manufacturer
        1. Reliability Determination
        2. Reliability Compliance
        3. Requires Planning
        4. Requires Definition of Failure
        5. Requires Description of Environment and Measurement Schedules

B. Use of Results of Tests

All testing should be done for a purpose. Test results should be used.

1. Simplest use is accept or reject product
    a. Determine acceptability of supplier
2. Learn whether product will meet specifications
3. Learn weak points of a product
4. Learn how to improve product

Failure Analysis

5. Learn capability of product to meet unusual and/or very rigorous environment. (One of the most hostile environments is the automobile.)

Day 3

TOPICS of SEMINAR ON CERTIFICATION and EVALUATION

THE PURPOSE and FUNCTIONS of QUALITY CERTIFICATION

1. To facilitate international trade in electronic component parts.
   a. By avoiding the necessity for 100% retesting by purchasers.
   b. To ease the resolution of quality problems if and when they arise on an international scale.
   c. To establish international rules for qualification approval of conformity, to establish rules for appeals and for resolution of any problems dealing with quality between buyer and seller of electronic and electrical component parts. (Operating Characteristic Curve)

2. To assist the product line committees of the IEC to establish parts specifications so that they can be used as procurement documents.
   a. The inclusion of the need for Qualification.
   b. The inclusion of inspection requirements and
   c. The testing and measurements needed to obtain and maintain the Mark (Certificate) of Conformity.

Day 4

THE ORIGIN and DEVELOPMENT OF QUALITY CERTIFICATION

A. Quality Certification originated many years ago with Certification of such items as -

1. Plywood
2. Boiler Tanks
3. Refrigeration Equipment
4. Underwriters listing of equipment to prevent fires.

B. TRIPARTITE - 1967

1. France, United Kingdom, Germany
    a. Vote as a block (group)
    b. Work together.

C. CENEL - Final Draft

First expanded to European Common Market. Next expanded to include the European Free Trade Association - a group of thirteen (13) countries. Hidden trade barrier.

D. IECQ

In May 1970 at the IEC meeting in Washington, D. C., two proposals were made by the U. S. Delegation to TC-56.

1. The Committee of Action investigate the requirements necessary for the IEC to operate an International Certification Plan.
2. Requested the Committee of Action to authorize TC-56 to establish a Working Group to prepare a proposal of a Certification Plan which could be used by any nation and later harmonized into an international plan.

Both proposals were accepted and Working Group 7 of TC-56 was organized to prepare the 'Proposal'.

Day 5

THE REQUIREMENTS and METHODS of MANAGEMENT of the STANDARDS and SPECIFICATIONS USED in QUALITY CERTIFICATION

A. The three areas of Management for the IECQ System in the U. S. A. are:

1. EIA - acting as the National Standards Organization
2. ECCB - acting as the National Authorized Institution
3. UL - acting as the National Supervisory Inspectorate

1. National Standards Organization

The Electronic Industries Association (EIA) is a U. S. Trade Association representing the U. S. Electronic Industry. EIA is responsible for preparing and issuing national standards and other documents associated with the IECQ System. EIA issues voluntary electronic standards for the electronics industry.

Many standards and specifications issued by the EIA have been adopted on a national scale by the American National Standards Institute (ANSI).

ANSI is an organization made up of many Trade Associations and Professional Organizations, such as, EIA, NEMA, (BEMA, AHAM, IEEE, ASQC, ANS, SAE, etc. Membership is also held by many large manufacturing companies, such as G.E.,ATT, IBM, Westinghouse, General Motors, Ford and many others.

ANSI has overall cognizance of all national standards and specifications in the U. S. A.

These standards and specifications are written by -

a. Committees within ANSI
b. Committees within member organizations
   (examples)

2. The U. S. National Committee of IEC - USNC of IEC - is the national organization which manages and has cognizance of all activities of the U. S. in the IEC. The USNC is an affiliate of ANSI.

   The USNC has established a separate organization, fully independent and incorporated within the laws of the U. S. A. and having separate financial responsibility. This organization, known as the ECCB (Electronic Components Certification Board) is responsible for management and implementation of all activities pertaining to the operation of the IECQ System within the U. S. A.

   ECCB consists of fifteen (15) members -

   Six (6) from electronic components manufacturers
   Four (4) from electronic equipment manufacturers
   Five (5) from general interest members or groups representing the electronic industry.

   The Chairman of the ECCB is the member of the CMC.

3. On the basis of proposals submitted to the ECCB by four organizations, the UL was chosen as the U. S. National Supervisory Inspectorate. The NSI (UL) is responsible forsurveillance of all procedures for quality assessment necessary for the System, and is also responsible for approving manufacturers, distributors and independent test laboratories and for suspension or withdrawl of such approval. Other areas of responsibility include:

   a. Qualification approval of components
   b. Surveillance of quality conformance inspection of components
   c. Audits of Procedures and Tests conducted under the system
   d. Proper use of the Certificate (Mark) of Conformity
   e. Issuance of Practices and Operating Procedures for approval, surveillance and audits as required

Day 6

BRIEFING on the QUALITY CERTIFICATION of ELECTRONIC COMPONENTS IN USA

A. Electronic Component Certification began in the U. S. A. with the writing of component specification by the combined effots of the Military Service (Army and Navy) in 1943. JAN Specifications

After the formation of the U. S. Air Force from the Army Air Force, the specifications became MIL Specifications.

These specifications required qualification approval and included quality requirements for qualification approval and inspection. They were used by the military services as procurement documents. At present, the Military Department has, what is known as, a QPL (Qualified Products Test) and a PPL (Preferred Parts List).

B. Approval was given to the U. S. A. Proposal made at the IEC Meeting in 1970 for an International Quality Certification System.

1. The Council established an interim Certification Management Committe to establish "Rules of Procedure" and "Basic Rules" for the operation of IECQ.
2. Ten (10) years later, the "rules" were finally adopted.
3. In January 1982 the IECQ System was finally approved and launched (became operational).
4. It is **my personal feeling, and the belief of others, that** many attempts were made to delay and/or stop this system from progressing by the European Free Trade countries.

Day 6

As of February 1982, there are eleven (11) countries whose National Supervisory Inspectorates have been approved. They are Australia. Belgium, Denark, France, Germany, Ireland, Israel, Japan, United Kingdom, Switzerland and United States.

Due to the fact, that there are very few general, sectional and/or detail IEC Specifications available which can be used for qualification testing and on the basis of which approval can be given (or the Mark of Conformity applied), the IECQ System is progressing very slowly.

A number of countries are busily writing General, Sectional and Detail Specifications which can be used in the IECQ System.

The U. S. A. National Supervisory Inspectorate with the assistance of the ECCB is working on a program to use a quality system similar to the IECQ System on a national and domestic basis.

Day 7

BRIEFING on the APPLICATION BY THE U. S. CERTIFICATION ORGANIZATION FOR MEMBERSHIP in the ICC OF IECQ SYSTEM and ITS APPROVAL BY ICC/IECQ

The U. S. A. was one of the first national committees that worked with other national committees to establish the Rules of Procedure and "The Basic Rules" of the IEC Quality Assessment System for Electronic Components (IECQ).

U. S. A. members working on these "Rules" were required to be particularly careful so that the rules would not be in violation of U. S. A. laws and regulations regarding international trade and national laws on trade, thereby, preventing U. S. companies from accepting agreements.

The U. S. National Committee of IEC accepted the responsibility for establishing the total organization for the IECQ System. The USNC established the Electronic Components Certification Board, a group of individuals from components manufacturers, component users and representatives from trade and professional organizations.
Slide of membershp (ECCB) as the NAI (National Authorized Institution). The NAI is responsible for management and implementation of all activities of the IECQ in the U. S. A. Maintain contact with CMC.

After a review of proposals submitted by three organizations to contract for the task of NSI, it was agreed that the Underwriters Laboratory (UL) be contracted to accomplish this task. The NSI is responsible for **surveillance** of all procedures for quality assessment necessary for the system. Maintain contact with and representation with ICC (Inspectorate Coordinating Committee).

The National Standards Organization (NSO) responsibilities have been accepted and undertaken by the Electronic Industries Associaton - a U. S. Trade Association representing the Electronic Industries.

The National Calibration Service for the IECQ System in the U. S. A. is provided through the U. S. National Bureau of Standards, which is part of the U. S. Department of Commerce and its system of calibration laboratories - which maintain traceability to the USNBS.

(Show Slides of U. S. National Organizations)

Day 8

THE REQUIREMENTS of NAI, NSI, NATIONAL STANDARDS INSTITUTE and NATIONAL CALIBRATION INSTITUTE - Taking the U. L. as an Example- What are the REQUIREMENTS of ANSI?

A. Responsibilities of NAI (US/ECCB)

1. Responsible for Management and Implementation of all activities in connection with the operation of the IECQ System in the U.S. A.

    a. Operate in the U. S. in accordance with the System's Basic Rules and Rules of Procedure.

    b. Shall implement the Basic Rules and Rules of Procedure in the U. S. A. by exercising approval authority over the practices and procedures as they pertain to IECQ of -

        1. NSO - (EIA)
        2. NSI - (UL)
        3. U. S. Calibration Service - (NBS)

2. Insures full compliance with the Rules of the System.

3. Review and act on appeals from decisions of the NSI. (Show Slide, page 4 of NSSA)

B. Responsibilities of NSI -

1. Responsible for surveillance of all procedures of Quality Assessment necessary for the System.

2. Responsible for approval of manufacturers, distributors and independent test laboratories.

3. Responsible for suspension or withdrawal of such approval.

4. Responsible for qualification approval of components.

5. Responsible for surveillance of quality conformance inspection of components. (Section 6)

6. Responsible for Audits. (Section 6)

Day 8

C. Responsibilities of NSO (EIA)

1. Responsible for preparing and issuing national standards and other documents associate with the IECQ System, such as -
    a. Quality Program Requirements for Electronic Component Manufacturers
    b. Procedures and Criteria for Approval of Electronic Component Testing Laboratories
    c. Calibration System Requirements
    d. Distribute Quality Bulletins and Information

Day 9

THE PROCEDURES and METHODS USED in GIVING APPROVAL to A COMPONENT (PRODUCT)

(Taking one kind of U. S. Component which has been certified as an example.)

Steps to be Taken in Giving Approval to A Component

1. The component manufacturer is reviewed to determine whether its quality control program is acceptable in accordance to the Quality Program Requirements contained in the National Statement of Surveillance Arrangements (NSSA), and has a written notice that he has been inspected and approved.

2. An appropriate set of specifications exist that have been approved by the relevant IEC Committee - or in the absence of an applicable IEC Standard, a provisional specification or other document which has been submitted to the CMC by a National Authorized Institution (NAI). These documents must conform to the requirements of the IECQ System. They must also be approved by the CMC prior to their use.

3. The component to be certified is qualified (given qualification approval.
   a. By testing by the manufacturer under supervision of the NSI in the approved test laboratory of the manufacturer.
   b. Or, by an independent test laboratory approved by the NSI
   c. Or, by the NSI laboratory.

4. A test report of the qualification test is reviewed by the NSI.
   a. If acceptable, a Certificate of Qualification Approval is issued to the manufacturer. (see Page 11 of NSSA (USA) The manufacturer is given permission to use the Mark of Conformity or a Certificate of Conformity.

Day 10

WHAT ARE THE PROCEDURES and METHODS USED AFTER CERTIFICATION IS GRANTED?

A. What are the procedures and methods of surveillance used for a qualified manufacturer, an independent laboratory and an independent distributor? (Illustrate with examples.)

B. What are the procedures and methods of survecilance used for a qualified component?

1. Surveillance of manufacturers, distributors and independent test laboratories is conducted on a periodic basis by the NSI. As stated in the US/NSSA, the US/NSI will condut an audit of each approved manufacturer, distributor and independent test laboratory at least once per year. During this audit, the NSI will examine all procedures and records for the past year and will review the testing in progress on any lots of qualified products undergoing inspection tests. The auditor may have prepared check lists or other aids so that audits are made in an equivalent manner for all manufacturers.

2. When information on the number of corrective actions required to be initiated is brought to the attention of the NSI, by either the Chief Inspector or by customers of an approved supplier, the NSI may perform unannounced special audits of all approved suppiers and conduct a rigorous surveillance inspection including the necessity of retesting certain lots or even requiring a requalification test.

   On the basis of the results of this special audit, one of three decisions may be made:

   a. Approval of the supplier is maintained.
   b. Approval may be suspended pending corrective actions required by the NSI.
   c. Approval may be withdrawn.

Day 11

WHAT ARE THE PROCEDURES of APPEAL AGAINST the CONCLUSION GIVEN to a CERTIFIED PRODUCT?

What are the procedures of appealing against a qualified product and damages for compensation? (Illustrate with examples.)

a. Appeal against the suspension or withdrawal of qualification approval is made in accordance with the National Arrangements (NSSA). It should be noted that appeals from decisions of the NSI and the NAI are national matters and are established by the national bodies of the country involved.
(See Procedure for Appeal Against Decisions of NSI)
U. S. - Sect. 3 Japan, Page 4

b. If an appeal is requested between countries or national organizations, the appeal is brought to the attention of the ICC (Inspectorate Coordinating Committee) by the NSI and/or to the CMC by the NAI's of the two countries involved.

c. Any appeal involving damages for compensation must be clearly negotiated and stated in orders between buyer and seller of the product concerned.

d. It should be noted that the Basic Rules discuss the legal provisions and the non-existance of liability of the CMC or the IEC. (See Section 11, "Legal Provisions of Basic Rules", p. 15)

e. Since the qualification testing and all inspection testing is accomplished on a statistical basis, a manufacturer, a distributor or the National Inspectorates can not be held financially responsible for the quality of each part in a lot. (See "Operating Characteristic Curve".)

Day 12

THE APPLICATION, the PROCEDURE of MANAGEMENT and the METHOD of SURVEILLANCE USED FOR QUALITY CERTIFICATES and QUALITY MARKS- (MARK of CONFORMITY)

After a review and approval of the Quality System of manufacturer, the NSI supervises the Qualification Test of the component or family of components for which approval is desired. The specification, test procedure, test equipment, test report of final results are all reviewed for conformance with the requirements of the specification. The qualification test may be conducted by the test laboratory of the manufacturer, an approved independent test laboratory or the test laboratory of the NSI. The financial arrangements for the qualification test should be completed and agreed upon by all relevant parties.

During initial qualification tests, the NSI may exercise close surveillance of the test procedure and the records maintained.

When the NSI is convinced that the Chief Inspector has a complete understanding of the procedures, sequences and records to be maintained, he may, during future qualification tests, elect to only review the test reports (results) and records to satisfy the requirements for approval. On the basis of these records, the NSI may approve the use of Certificate (or mark) of Conformity.

The Certificate(or mark) of Conformity also implies that all lots of future manufacture of the component are inspected in accordance with the specification. The responsibility for accomplishing this inspection rests with the Chief Inspector of the manufacturer.

The NSI conducts periodic reviews of each approved vendor to determine that the correct procedures are maintained in accordance with the three major Documents of the System.

a. Basic Rules
b. Rules of Procedure
c. National Statement of Surveillance Arrangements

Day 12

Any problems found by the NSI during the surveillance trips must be corrected as outlined in the NASSA. The NSI will advise the Chief Inspector what problems exist and what corrective action is to be completed and whether parts can or can not be shipped with the Certificate(mark) of Conformity.

(See 9.2 Rules of Procedure for Description of NSSA.)

Day 13

WHAT ARE THE DIFFERENCES BETWEEN THE EXISTING MARKING SYSTEMS USED IN VARIOUS COUNTRIES and THAT OF THE QUALITY CERTIFICATION SYSTEM?

There are many marking systems used in various countries of the world. However, they are all national systems based on the individual country's rules, regulations and laws. For example, in the U. S. A. we have the U. L. listing for safety or accident prevention. This listing is usually required by the National Electric Code and/or the 'Electrical Code of the Individual States of the U. S. A.'. This listing is used by the insurance companies for insurance purposes.

There are marking systems for other categories such as, plywood, boilers, pressure vessels, refrigeration units, safety glass, etc., and certification given to the product being tested and listed as meeting certain requirements. Many countries have these diferent marking systems.

The Quality Certification System or Certificate (or mark) of Conformity certifies that the product has been made by a manufacturer, sold by a distributor or tested by an independent laboratory that is a participant in the IECQ SYSTEM. This indicates that the manufacturer has been reviewed by the NSI of his country (or a member country); has qualified his product in accordance with the requirements of the IECQ Basic Rules, the IECQ Rules of Procedure and the National Statement of Surveillance Arrangements of his country.

Day 14

THE FUTURE DEVELOPMENT OF THE EVALUATION TECHNIQUES OF COMPONENTS

With the increase in complexity of electronic components and the trend towards miniaturization, the future of the evaluation techniques for these electronic components will develop toward automatic procedures.

There are many automatic type testors now available and considerable development is being conducted to increase the automatic capability and speed of all type of automatic testors.

The future development of active components toward micro-miniaturization, higher speeds, increased memory in such devices as RAM'S and ROM'S and microprocessors and lower power dissipation will require test equipment and measuring equipment to keep up with this progress.

Environmental test equipment will be developed so that many <u>different</u> types of components will be capable of being subjected to different environments, such as high heat, cold, humidity, (hermiticity) atmospheric pressure, etc. at the same time. This environmental test equipment will be capable of having electric power and other electric signals supplied so that the components under test wil be dynamically operated under test. Measurements will be able to be taken during the test conditioning period.

New groups of components will be developed that may require new approaches to testing and measuring. Components for fiber optics control and transmission of signals are presently being developed and testing and measurment techniques will be developed for these devices.

New techniques are presently used in "real time" x-ray examination. Acoustical Scanning Microscopes are being developed to examine traces or parts that have been covered by other materials. (Olympus and Leitz). Thermal scanning devices or "hot spot" locators are being developed so that temperature on micron size and sub-micron size traces or spots can be observed and the temperature measured.

Day 14

Devices and combinations of devices are being discussed with one-hundred, two-hundred and more pin arrangements. This will require new and advanced thinking of test and measurement equipment.

It is difficult to predict in which direction future development of electronic components and therefore, test and measurement techniques will go in the future. However, it is my prediction that the next ten (10) years will show a great change in electronic devices and the techniques of measurement.

Day 15

BESIDES USING THE "COMPONENT HOUR" METHOD, ARE THERE ANY OTHER METHODS USED IN THE QUALITY EVALUATION OF COMPONENTS?

The "Component Hour" method is used for evaluation and determining failure rates for components that have no mechanical type operation such as fixed resistors, fixed capacitors, fixed inductors, diodes, transistors, integrated circuits and similar components.

For components with a mechanicsl type operation, measures, other than hours, may be used. In most instances, this measurement is made in "cycles". Potentiometers and variable capacitors may be measured in number of rotations or cycles. Swtiches and relays may be measured in number of "on/off" cycles. Connectors may be measured in number of mating/demating cycles.

The method used in evaluating a component depends a great deal on its type of operation.

In many instances when cycles or number of events are used as an evaluation method, other factors arise, such as speed with which the operation is conducted, atmosphere and temperature in which the operation is conducted will also have a great effect on the evaluation.

What must be considered in evaluating a component is "the way it is to be used". The basic application of the component will determine its reliability/failure rate considerably.

By application we mean -

a. Environment/Protection
b. Type of Operator (Knowledge and Experience)
c. Strength of Operator

Day 16

WHAT ARE THE METHODS USED IN U. S. A. FOR THE EVALUATION OF FAILURE RATES OF COMPONENTS?

How are the failure rate data listed in the U. S. Component Data Handbook obtained?

How are the correction factors determined?

Failure Rate Data are obtained in three ways -

a By predicting in accordance with models established, such as MIL-HDBK - 217.

b. By testing of operation of component parts in test laboratories under known conditions.

c. By field experience and maintaining accurate records.

1. Accomplished by Military Services.
2. Accomplished by Communications Organizations, such as telephone communication, satellite communication

Rome Air Development Center and a contractor to RADC, Illinois Institute of Technology, are the two prime sources for determining failure rates. The work, of course, is accomplished primarily on military equipment.

The American Telephone and Telegraph Company also has a considerable effort in determining failure rates. This is done to improve the reliability of its communications equipment, and thereby, lower the life cycle cost.

Many of the large component manufacturers maintain test programs to determine failure rates of components they manufacture. This is accomplished to improve the quality and reliability of their parts, as well as improve their market position.

Day 16

System manufacturers, such as satellite producers, also maintain records of failure rates and use these failure rates in design of future systems. Redundancy and type of redundancy is determined on the basis of experienced failure rate.

In many cases, contracts for satellites are based on active life, and incentive payments may be made when the equipement operates to agreed upon performance longer than given periods.

Day 17

BRIEFING ON THE RELIABILITY EVALUATION METHODS OF SEMICONDUCTOR DEVICES IN THE U. S. A.

Most evaluation methods of semiconductor devices are contained in military specifications, but are utilized by many users in ordering/purchasing semiconductor devices and other electronic components. Electronic parts used for domestic, commercial and industrial equipment, when purchased in large quantities, usually have specifications written to describe the part being purchased. These specifications may refer to tests included in the mentioned MIL specifications or have special tests specified which require special requirements for specific applications.

Frequently used MIL Test Specifications are:

A. MIL-STD-202 Test Methods for Electronic and Electrical Components - (Page 3 of 202)

This specification includes:

1. Environmental Tests
2. Physical-Characteristic Tests
3. Electrical Characteristic Tests

B. MIL-STD-883 Test Methods and Procedures for Microelectronics This specification is referenced in both MIL-S-19500 - Semiconductor Devices, General Requirements For and MIL_M-38510 - Microcircuits, General Specification For.

C. MIL-STD-750 Test Methods for Semiconductor Devices and is referenced in the general specification for Semiconductor Devices - MIL-S-19500

D. MIL-STD-810 Testing Electronic Equipment

Day 17

E. MIL-STD-781 Reliability Design Qualification and Production Acceptance Tests: Exponential Distribution

This standard gives testing plans for various types of military equipment. However, similar plans are applicable to consumer, commercial and industrial type equipment. The tests may be altered (changed) to make them less rigorous depending on the end use.

Also shown in this standard are a number of sequential test plans and O.C. curves for various MTBF's and Θo and Θ_1

In no case can this standard be called out as an applicable document. It should be used as a reference document from which each requirement is assessed in terms of <u>need</u>

(Show definition, Page 3 and 4 and Page 85 O.C. and Page 66.)

Day 18

HOW SHALL WE SAMPLE AND EVALUATE SWITCHES, CONNECTORS, POTENTIOMETERS, and TEMPERATURE SENSITIVE COMPONENTS?

What are the methods used in evaluating the failure rate of these components?

A. Sampling Plans are dependent on the percent defective that the purchaser or the manufacturer is willing to accept and the confidence factor desired in the decision of acceptance or rejection.

MIL-STD-105D is the standard used in the U. S. A. to determine sampling plans. This document has been accepted by the IEC and has been published as Document 410.

For the IECQ SYSTEM, Generic, Sectional and Detail Specifications are being proposed. Copies of the proposed specifications for Electromechanical Switches are to be shown.

The tests for Qualification Approval and Lot Testing are given in the Sectional Specification.

B. Evaluating the failure rate of electromechanical components, such as switches, connectors, potentiometers and relays is a difficult problem. The difficulty arises from the lack of knowledge on how the component is to be used in its application. For example, questions, such as -

1. How often will the switch be operated or how often will the connector be mated and unmated?
2. In what type of environment will the components be used?
3. At what temperature range will these components be subjected?

Day 18

The manufacturer of switches rarely has the knowledge of the application and environment in which his product will be used. Therefore, he must design his product to those applications he is most familiar with or the application specified by his customers.

Qualification tests which evaluate the design may have requirements for Endurance (number of operations capable without mechanical failure), Electrical Failure (failure to open or close), or Contact Resistance Change and Contact Bounce Requirements. For example, a manufacturer may announce that his switches are designed to withstand an average of 50K, 100K or 1 million operations without a mechanical failure or a change in contact resistance of X% (or maximum value) at a given temperature.

With statements (or requirements of this type), a basis for testing and evaluating switches (or other electromechanical devices) is established.

In predicting reliability (or failure rate) of electromechanical devices, a failure rate per hour is established so that one can combine the failure rates of components to obtain a Mean Time Between Failure (MTBF).

(Show slides of Reliability Prediction of Switches)

Day 19

A. WHAT ARE THE KEY POINTS IN THE RELIABILITY EVALUATION TECHNIQUE USED FOR LSI?

B. WHAT ARE THE KEY MEASURES USED AND THEIR CHARACTERISTIC FEATURES?

A. (Show Slide, Page 7 of 38510)
In my opinion, the key **points** in Reliability Evaluation Technique for LSI are life tests at rated voltage and maximum temperature. (See Test 1016 - Life/Reliability Characterization Tests and Test 1015.2 Burn-In Test and 1005 of 883B.) Burn-In is used as an additional screen by users of components requiring high reliability.

It must be realized that the methods and specification discussed considerably **enhances** the cost of the items and should be used only where required. The economics of life testing and burn-in must be thoroughly studied. (Show slides of cost/savings.)

Burn-In is a technique of eliminating early failure or removing those units that have been possibly damaged during the processing steps or have small defects caused by basic material deficiences.

B. The term LSI (Large Scale Integration) refers to any microelectronic device having more than 100 gates (400 transistors). VLSI (Very Large Scale Integration) refers to any microelectronic device having more than 1000 gates (4,000 transistors) using the figure or transistor, count as 4 per gate.

Day 19

B. (continued)

Since there are many different types of microelectronic devices, try ing tc categorize the kety points in evaluating or testing as a class is practically impossible.

To give you some idea of the operating conditions and characteristics of TTL (TRANSISTOR-TRANSISTOR LOGIC), I have a listing of these. (Show Slides of IV and V of 883B)

Each general specification, such as MIL-S-19500, MIL-M-39510 gives the general specifications for the components covered. Detail requirements and specific characteristics are given in detail device specifications referred to as slash sheets. Each slash sheet covers only one device type.

Day 20

BRIEFING ON THE "CLIMATIC TEST SEQUENCE" OF DIFFERENT COMPONENTS IN THE IEC STANDARDS

If we change the test sequence, will there be any difference in the test results?

The climatic test sequence is usually specified in the Generic Standard of the part in question. This sequence may be altered by the detail specification.

To me, the test sequence is an important element for qualification testing which is basically a test for the design of a product. The test sequence should really be arranged to determine the capability of the design to withstand some of the worst case applications of the part being tested.

For example, a test sequence of -

A. Vibration
Humidity Endurance
Low Temperature
High Temperature

would be more severe than -

B. Low Temperature
High Temperature
Humidity Endurance
Vibration

In sequence A -

The vibration test may cause small cracks, break hermeticity seals or open areas around leads emerging from encapsulating material. Then, during the humidity conditioning, moisture could enter these cracks which would freeze during the low temperature conditioning which would further open the small cracks. The high temperature

Day 20

may then expand the metal leads or other material near or in the region of the original crack. Measurements after this series would show this - especially, after a life test or endurance test.

In series B, the cracks would not be opened since the vibration is accomplished at the end.

I am not particularly pleased with some of the test sequences shown since I believe they were not particularly well thought-out. This is more apparent on the electromechanical parts. As mentioned at the beginning, testing must be accomplished for a purpose and for the basic application of the part or the equipment in question.

Parts used in television sets in homes or offices may not require the severity of tests that parts used in railroad signaling and communication equipment require. Parts used in medical electronic equipment may not need the severity of tests that parts used in electronic equipment in aircraft require.

Here we have to distinguish between severity of testing and Reliability. Reliability of medical equipment or electronic equipment used in aircraft must be very high since the safety of equipment used in aircraft must be very high since the safety of people's lives may be endangered.

The application of the parts must be considered in determining test severity and reliability - two different type requirements.

Day 21

TYPICAL FORMS USED TO RECORD TESTING

WHAT ARE THE TEST RECORDS and TEST REPORT FORMATS USED BY UNITED STATES LABORATORIES FOR EVALUATION TESTS OF COMPONENTS?

The test records maintained by test laboratories depend on the type of test being conducted, and the customer to whom the product and test reports are being supplied. In most instances, the test record is a copy of the test report which includes the test results.

The test record format can and does vary from a very simple one to a very complex format.

In all cases, all the pertinent information of the test must be included. This information includes:

1. Type of component being tested with all ratings and tolerances.
2. Specification or requirements to which the component is being tested.
3. Date (or dates of test).
4. Measuring equipment and other special equipment being used. Model number, serial number, manufacturer, calibration date (if required) and mode (manual or automatic) being used.
5. Name of equipment operator.
6. Number of units being tested.
7. Other pertinent information needed to fully describe the test.
8. Disposition of the units tested.

Some test customers require serialization of the parts being tested so that sample readings may be audited.

(Some samples of test records are to be shown.)

QUALITY ASSURANCE

FIRST ARTICLE INSPECTION SHEET

VENDOR ______________________

JOB NUMBER ______________________

PART NUMBER ______________________

CHARACTERISTIC MEASURED	TOL.	ACTUAL READING	DIFFERENCE

SKETCH OR SPECIAL INSTRUCTIONS OR CRITICAL AREAS

QUANITY__________ SAMPLE__________

TEST DISCREPANCY REPORT

REPORT NUMBER T 11146

PROJECT ____________

FAILURE ANALYSIS REQUIRED: ☐ YES ☐ NO

01

02

GO TO LINE NUMBER CORRESPONDING TO "TL" (TEST LEVEL)

1 -SYSTEM TEST 2 -SUBSYSTEM TEST 3 -ASSEMBLY TEST 4 -SUBASSEMBLY TEST 5 -DETAIL SUBASSEMBLY TEST 6 -COMPONENT PART TEST

1
2 03

DESCRIPTION OF SYSTEM/SUBSYSTEM MALFUNCTION AND REWORK

SIGNATURE DATE

3 04

ASSEMBLY PART NO. | SERIAL NO. | ASSEMBLY NAME | DISPOSITION | OTHER

STOP HERE IF THE DISCREPANCY WAS DETECTED AT SYSTEM/SUBSYSTEM LEVEL TEST AND THE ABOVE ASSEMBLY WILL BE REWORKED BY ANOTHER DIVISION/COST CENTER

05

VERIFICATION ☐ YES ☐ NO | FAILURE TYPE ☐ PRIMARY ☐ SECONDARY

DESCRIPTION OF ASSEMBLY MALFUNCTION AND REWORK

SIGNATURE DATE

4 06

SUBASSEMBLY PART NO. | SERIAL NO. | SUBASSEMBLY NAME | CIRCUIT DESIGN | DISPOSITION | OTHER

STOP HERE IF THE DISCREPANCY WAS DETECTED AT ASSEMBLY LEVEL TEST OR ABOVE AND THE SUBASSEMBLY WILL BE REWORKED BY ANOTHER DIVISION/COST CENTER

07

VERIFICATION ☐ YES ☐ NO | FAILURE TYPE ☐ PRIMARY ☐ SECONDARY | MANUFACTURER'S NAME

DESCRIPTION OF SUBASSEMBLY MALFUNCTION AND REWORK

SIGNATURE DATE

5 08

DETAIL SUBASSEMBLY PART NO. | SERIAL NO. | DETAIL SUBASSEMBLY NAME | CIRCUIT DESIGN | DISPOSITION | OTHER

STOP HERE IF THE DISCREPANCY WAS DETECTED AT SUB/ASSY LEVEL TEST OR ABOVE AND THE DETAIL SUB/ASSY WILL BE REWORKED BY ANOTHER DIVISION/COST CENTER

09

VERIFICATION ☐ YES ☐ NO | FAILURE TYPE ☐ PRIMARY ☐ SECONDARY | MANUFACTURER'S NAME

DESCRIPTION OF DETAIL SUBASSEMBLY MALFUNCTION AND REWORK

COMPLETE THE FOLLOWING FOR EACH COMPONENT PART ADJUSTED, REWORKED OR REPLACED

6

		CIRCUIT DESIGNATION	COMPONENT PART NO.	COMPONENT NAME	LOT NO. OR S/N	DEFECT CODE	MANUFACTURER'S NAME	[illegible]
10	1							
11	2							
12	3							
13	4							

COMMENTS/RETEST INSTRUCTIONS

THE FOLLOWING LINE MUST BE COMPLETED FOR ALL TEST DISCREPANCY REPORTS

14 ☐ YES ☐ NO

TEST DATA

DATE STARTED	CUSTOMER	TECHNICIAN (SIGNATURE)
DATE COMPLETED	SPECIMEN DESCRIPTION	ENGINEER (SIGNATURE)
TEMPERATURE	TYPE OF TEST	ENGINEER
HUMIDITY	MANUFACTURER	JOB NUMBER
SPECIMEN NUMBER	TEST SPECIFICATION	

468

TEST DATA

DATE STARTED	CUSTOMER	TECHNICIAN (SIGNATURE)
DATE COMPLETED	SPECIMEN DESCRIPTION	ENGINEER (SIGNATURE)
TEMPERATURE	TYPE OF TEST	ENGINEER
HUMIDITY	MANUFACTURER	JOB NUMBER
SPECIMEN NUMBER	TEST SPECIFICATION	

SPECIMEN NUMBER	DATE	TIME	TEMPERATURE (°)						( )	REMARKS
			TC 1	TC 2	TC 3	TC 4	TC 5	TC 6		

VLI 412-01

EQUIPMENT LIST

JOB NUMBER ____________

TEST DESCRIPTION: ______________________________

EQUIPMENT DESCRIPTION	MANUFACTURER	MODEL NUMBER	ASSET NUMBER	RANGE	ACCURACY	CALIB DATE	CALIB PERIOD

VL1-420-02

TEST DATA

DATE STARTED	CUSTOMER	TECHNICIAN (SIGNATURE)
DATE COMPLETED	SPECIMEN DESCRIPTION	ENGINEER (SIGNATURE)
TEMPERATURE	TYPE OF TEST VISUAL EXAMINATION	ENGINEER
HUMIDITY	MANUFACTURER	JOB NUMBER
SPECIMEN NUMBER	TEST SPECIFICATION	

SPECIMEN NUMBER	SERIAL NUMBER	PART OR MODEL NUMBER	LOT NO.	REMARKS

404

TEST DATA

DATE STARTED	CUSTOMER	TECHNICIAN (SIGNATURE)
DATE COMPLETED	SPECIMEN DESCRIPTION	ENGINEER (SIGNATURE)
TEMPERATURE	TEST OF TEST ACCELERATION	ENGINEER
HUMIDITY	MANUFACTURER	JOB NUMBER
SPECIMEN NUMBER	TEST SPECIFICATION	

SPECIMEN NUMBER	DATE	AXIS	TIME START	TIME STOP	RADIUS (IN.)	RPM	LEVEL ( )	REMARKS

414

TEST DATA

DATE STARTED	CUSTOMER	TECHNICIAN (SIGNATURE)
DATE COMPLETED	SPECIMEN DESCRIPTION	ENGINEER (SIGNATURE)
TEMPERATURE	TYPE OF TEST SHOCK	ENGINEER
HUMIDITY	MANUFACTURER	JOB NUMBER
SPECIMEN NUMBER	TEST SPECIFICATION	

SPECIMEN NUMBER	DATE	AXIS	LEVEL (g)	PULSE DURATION (MS)	NO OF SHOCKS	REMARKS

TEST DATA

DATE STARTED	CUSTOMER	TECHNICIAN (SIGNATURE)
DATE COMPLETED	SPECIMEN DESCRIPTION	ENGINEER (SIGNATURE)
TEMPERATURE	TYPE OF TEST SALT SPRAY	ENGINEER
HUMIDITY	MANUFACTURER	JOB NUMBER
SPECIMEN NUMBER	TEST SPECIFICATION	

SPECIMEN NUMBER	DATE	TIME	SALT SOLUTION			COLL. RATE (ML/HR.)		TEMP. (°F)	REMARKS
			SP. GR.	% NaCl	pH	VES. 1	VES. 2		

TEST DATA

DATE STARTED	CUSTOMER	TECHNICIAN (SIGNATURE)
DATE COMPLETED	SPECIMEN DESCRIPTION	ENGINEER (SIGNATURE)
TEMPERATURE	TYPE OF TEST EXPLOSIVE ATMOSPHERE	ENGINEER
HUMIDITY	MANUFACTURER	JOB NUMBER
SPECIMEN NUMBER	TEST SPECIFICATION	

SPECIMEN NUMBER	DATE	TIME	TEMPERATURE (°F)		ALTITUDE (X 1000 FT.)	EXP. MIX. VERIFIED (✓)	REMARKS
			AIR	SPEC.			

411

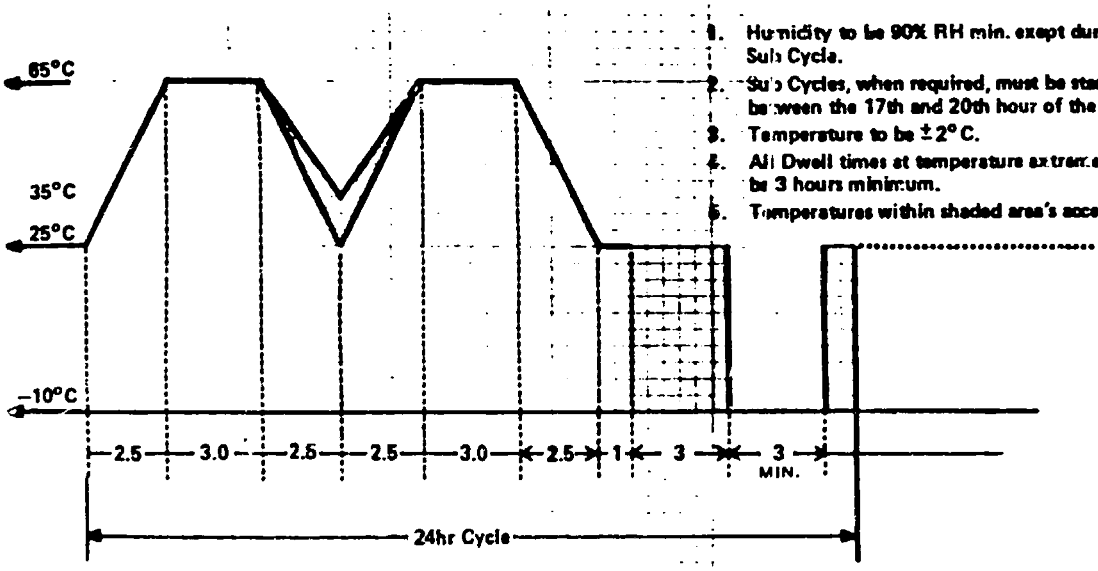
TEST DATA

DATE STARTED	CUSTOMER	TECHNICIAN (SIGNATURE)
DATE COMPLETED	SPECIMEN DESCRIPTION	ENGINEER (SIGNATURE)
TEMPERATURE	TYPE OF TEST TEMPERATURE- HUMIDITY	ENGINEER
HUMIDITY	MANUFACTURER	JOB NUMBER
SPECIMEN NUMBER	TEST SPECIFICATION	

SPECIMEN NUMBER	DATE	TIME	TEMP. (°F)	HUMIDITY (% RH)	CYCLE NO.	REMARKS

TEST DATA

DATE STARTED	CUSTOMER	TECHNICIAN (SIGNATURE)
DATE COMPLETED	SPECIMEN DESCRIPTION	ENGINEER (SIGNATURE)
TEMPERATURE	TYPE OF TEST MOISTURE RESISTANCE	ENGINEER
HUMIDITY	MANUFACTURER	JOB NUMBER
SPECIMEN NUMBER	TEST SPECIFICATION	



1. Humidity to be 90% RH min. exept during Sub Cycle.
2. Sub Cycles, when required, must be started between the 17th and 20th hour of the Cycle.
3. Temperature to be ± 2° C.
4. All Dwell times at temperature extremes shall be 3 hours minimum.
5. Temperatures within shaded area's acceptable.

CYCLE NO.	DATE	TIME		SUB-CYCLE PERFORMED	REMARKS
		START	STOP		

EQUIPMENT USED:	MANUFACTURER	MODEL	ASSET NO.	CAL DATE	CAL PERIOD

VLI 407-02

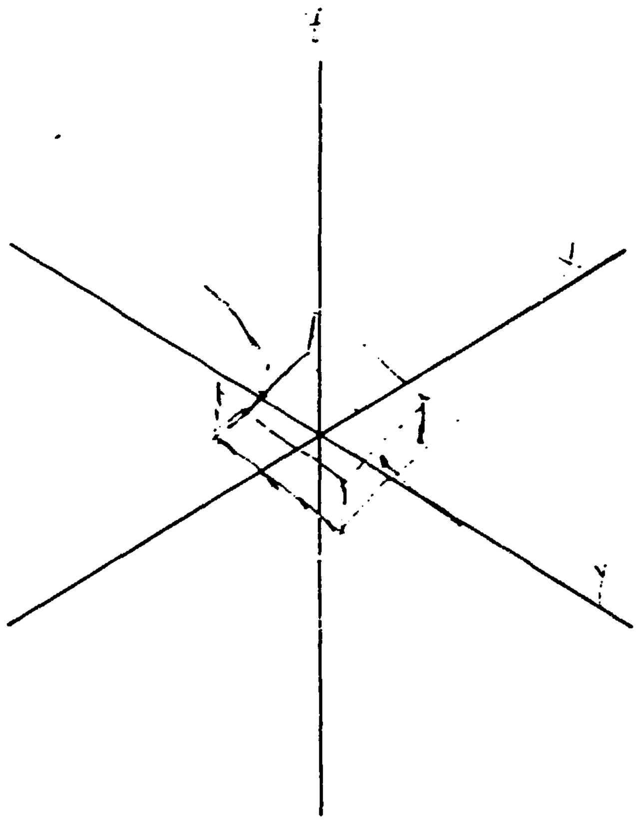
TEST DATA

DATE STARTED	CUSTOMER	TECHNICIAN (SIGNATURE)
DATE COMPLETED	SPECIMEN DESCRIPTION	ENGINEER (SIGNATURE)
TEMPERATURE	TYPE OF TEST VIBRATION	ENGINEER
HUMIDITY	MANUFACTURER	JOB NUMBER
SPECIMEN NUMBER	TEST SPECIFICATION	

SPECIMEN NUMBER	DATE	AXIS	TIME START	TIME STOP	VIBRATION FREQUENCIES AND LEVELS	REMARKS

TEST DATA

DATE STARTED	CUSTOMER	TECHNICIAN (SIGNATURE)
DATE COMPLETED	SPECIMEN DESCRIPTION	ENGINEER (SIGNATURE)
TEMPERATURE	TYPE OF TEST	ENGINEER
HUMIDITY	MANUFACTURER	JOB NUMBER
SPECIMEN NUMBER	TEST SPECIFICATION	



DEFINITION OF AXES

ELECTRONIC COMPONENT TESTING - SOME DEFINITIONS

BY

ALAN D. ALBERT

It has recently been discovered that everyone is not an expert on electronic component testing. The following material has been prepared to help remedy this apalling situation.

ELECTRONIC COMPONENT SCREENING

Definition (Webster's New World Dictionary, 2nd College Edition)

To Screen:
- (a) to sift through a coarse mesh so as to separate finer from coarser parts.
- (b) to interview or test so as to separate according to skills, personality, aptitudes, etc.

Electronic component screening is basically a Quality Assurance activity. Its purpose is to separate those components with manufacturing defects from the total population. The defects may be either actual or latent. To the degree that components with latent defects are removed from the population, screening becomes a Reliability activity, since Reliability is concerned with performance over time.

The screening process consists of sequences of failure mechanism activators followed by failure detectors for latent defects or detectors only for actual defects. Some examples of these for I.C.'s are as follows:

Actual Defects

Defect	Detector
Poor die attach, bad bonds	X-Ray
Loose particle inside a cavity package.	PIND
Bad seal on hermetic packages	Hermeticity (fine and gross leak)
Broken packages, leads, etc.	Visual inspection.
Non-functional parts.	Electrical test.

Latent Defects

Defect	Activator	Detector
Microcracks	Temperature cycling	Electrical Test
Surface impurities	Burn-in	Electrical Test
Poor die attach	Centrifuge	Electrical Test
Mismatched thermal coefficients of expansion in package seal region.	Thermal shock	Hermiticity
Weak bonds	Shock and/or vibration	Electrical Test

Screening is, of course, applied to all the parts in a given population. Screens may consist of as little as a single detector or may consist of a number of sequences of activators and detectors. These must be chosen to detect and activate/detect the most common actual failures and latent failure mechanisms for the given type of part. Rote application of some screening procedure can be quite wasteful. Screens for rare or non-existent failure types can be performed, and worse, some common failure types may not be detected. Performing a hermeticity test on an encapsulated part is a waste, and not performing temperature cycling followed by electrical testing at high temperatures on parts known to suffer from micro-cracks is criminal.

The government generally specifies standard screens as in MIL-STD-883B, Method 5004.4, and many large companies have their own standard screens. For any given part type, these may or may not be optimum screens. Typically, the government tends to overkill just to make "sure", but still there may be some particular screen sequence indicated for some particular part that is not a part of the standard procedure.

The principal business of test laboratories is electronic component screening. Very few people anywhere, and this includes component engineers, know as much about this type of testing as bonafide test engineers. Component users have "real" screening needs. They have component problems which result in poor board/ system/yields and consequent reduction of profitability. The test engineer's job is to solve these real component problems in a cost effective manner. The actual screening procedures are a necessary part of the service, but knowing how to use them is also a vital part of expert service.

ELECTRONIC COMPONENT QUALIFICATION

Definition (Webster's New World Dictionary, 2nd College Edition)

Qualification: A condition that must be met in order to exercise certain rights.

Electronic component qualification is a Quality Assurance activity. Its purpose is to determine if a particular product, batch or lot meets established quality requirements.

The qualification process consists of a number of tests and/or examinations performed on a small sample taken from a larger population of parts. These tests and/or examinations are usually evaluated by some statistical sampling plan (eg: Lot Tolerance Percent Defective (LTPD) or Acceptable Quality Level (AQL)). Many of these tests and/or examinations are destructive to the parts and none of the parts used in a qualification are intended for any eventual use. Some examples of these for I. C.'s are as follows:

Electrical tests; static, dynamic switching, functional, at various temperatures.

Bond strength test.

Die shear test.

Solderability.

1000 hour operating life test.

Internal visual inspection (microscope and SEM)

Qualifications may consist of as little as a DPA (destructive parts analysis) on a sample of only 3 parts or may consist of a large battery of tests and examinations. The government generally specifies a standard qualification procedure as in MIL-STD-883B, Method 5005.5. Many companies have their own standard procedures for component qualification.

Care must be taken in costing these jobs, as they can become quite complex and very expensive. They should be carefully viewed as to how much resource is tied up in their performance, and whether or not the qual is an adjunct to screening activities.

ELECTRONIC COMPONENT CHARACTERIZATION

Definition	(Webster's New World Dictionary, 2nd College Edition)
To Characterize:	To describe or portray the particular qualities, features or traits of

Electronic component characterization is essentially an Engineering study activity. Its purpose is to determine the actual operating characteristics of some part type. These data are intended to be used by design engineers when they use that part type. Characterizations are engineering intensive and require that any test system being used be fully operational and well calibrated.

The characterization process is not standard at all, and each time such a study is requested, a thorough engineering analysis of the customer's needs must be performed with the customer. Improper bidding on characterization jobs has often been quite costly to testing laboratories.

Some examples of characterizations for I. C.'s are as follows:

1) Simple electrical characterization, consisting of electrical testing to a spec with read and record data, often used as a tool in vendor selection.

2) Electrical characterization, consisting of many tests with one or more varying parameters with read and record data and usually some statistical treatment of the data.

The most common forms for statistical presentations are:

a) distributions of parameters with mean, standard deviation(s), high/low values, etc.

b) histograms, and

c) shmoo plots.

These electrical characterizations are used in vendor selection, spec development, process evaluation, systems design, etc.

3) Thermal characterizations, which may be performed concurrently with electrical characterizations, consisting of

repeated electrical tests at various temperatures.

These are especially needed by users with very high and/or low temperature applications, such as automobiles, outdoor equipment in general, oil well drilling, etc.

4) Reliability evaluations are also characterizations, consisting of one or more accelerated life tests.

The purpose of a reliability characterization is to help determine the expected life of a part type under some operating condition(s). The techniques used are various and generally use all or most of the test capabilities present in testing laboratories.

Characterizations, being engineering intensive, tie up a considerable amount of manpower for limited return. Properly selected, however, characterizations can have considerable value. They often lead to large screening opportunities; they allow the development of screening test programs early-on in the product life cycle; they help create a climate of technical excellence; and they actually support a small and highly competent engineering staff that is above and beyond what is normally found at independent test labs. Properly utilized, characterization testing can help to develop and maintain a leading edge in testing technology.

THE JOYS OF COMPONENT SCREENING

By

ALAN D. ALBERT

The consumption of "uncooked" electronic components can produce quite a case of financial "indigestion". With rising costs and falling productivity these days, it is imperative that we find simple and effective means for continued viability. One such means, all too often overlooked, is component screening. Although component screening has been around for many years, the principal users have been DOD and NASA as a means to achieve the highest possibile reliability within a given technological area.

Component screening has been viewed by many as "too expensive" in this highly competitive marketplace. The truth of the matter is that component screening, done correctly, results in significant cost savings as well as all those nice things that result from producing quality products. One of these nice things that immediately increases profit is the decreased cost of sales. This occurs when your well satisfied customers become a free sales force.

Component screening procedures, at their simplest, detect defective parts as they come from the manufacturer. More elaborate screening procedures involve activation of various failure mechanisms through the use of mechanical, thermal and/or voltage stresses, followed by tests to detect those parts that have gone bad. These types of screening procedures are designed to accelerate the latent defects inherent in some parts, while not causing any damage to a "normal" part.

The costs of screening vary from as little as ten cents per part for the simple screens to as much as two or three dollars per part for a high reliability screen. Any of these screens will cull defective parts from the original populations and thereby increase the yield of the equipment using these parts. Typical yields for circuit boards as they are built today are startlingly low when using unscreened parts (see Table 1).

If only 3% of the population of parts is bad, a small board of 50 parts has a mere 21.8% yield. Using that same part population, if a board has only 200 parts, the yield has dropped to 0.26% with an average of 6 bad parts per board (see Tables 2-6 for detailed bad part distribution data). This would be a total disaster in any manufacturing activity, and the cost of finding all 6 bad parts on one board is prohibitive. Fortunately, for most manufacturing operations, these failures are not usually all present at the same moment, but rather occur one at a time over the early operating period of the equipment.

In general, the difficulty of finding more than one bad part on a board at the same time can cause quite a jump in rework costs. The actual costs will vary considerably with individual equipments, available test systems, experience of the personnel, It should also be noted that rework or repair costs increase by another factor of from ten to one hundred when one of these defects shows up in a system that has already gone out into the field. As if that isn't enough, there is also the cost (to someone) of loss of production (system downtime) plus the loss of prestige and credibility, and in some cases, direct financial penalties.

By using the Tables as above, it is not difficult to get some idea of the relative costs of screening versus using "uncooked" parts. The good part probability of 0.999 is relatively easy to achieve using inexpensive screens. The high good part probability of 0.9999 is what can be achieved through one of the more complex screening procedures. Even though the cost for such screening may be of the order of two to three dollars per part, it is still cost effective when the total number of parts on the board is high and/or the rework costs are high.

Historically, only the high reliability government users have been willing to pay for that level of screen, but it can easily be seen to be quite cost effective in many situations. The good part probabilities of 0.97, 0.98 and 0.99 are illustrative of the range often found in semiconductors as they come from the factory.

In actual practice, since many different part types are usually found on any one circuit board, the probabilities of good parts will vary from part type to part type and from manufacturer to manufacturer. The cost savings calculations become a little more complicated, but the end result is about the same.

The joys of component screening are manifest. They are a real cure for financial "indigestion".

NUMBER OF PARTS ON A BOARD

	BOARD* YIELD AVERAGE No. of Bad Parts on a Board	50	100	200	300	400
GOOD PART PROBABILITIES	.97	21.8%	4.8%	0.23%	0.01%	0.005%
		1.5	3	6	9	12
	.98	36.4%	13.3%	1.8%	0.23%	0.03%
		1.0	2.0	4.0	6.0	8.0
	.99	60.5%	36.6%	13.4%	4.9%	1.8%
		0.5	1.0	2.0	3.0	4.0
	.999	95.1%	90.5%	81.9%	74.1%	67.0%
		0.05	0.1	0.2	0.3	0.4
	.9999	99.5%	99.0%	98.0%	97.0%	96.0%
		0.005	0.01	0.02	0.03	0.04

TABLE 1

*If p = the probability that a part is good and if N = the total number of parts on a board, then the probability that the entire board is good = $P = p^N$ and board yield = 100 P%. The probability that a board has exactly B bad parts = $P(B) = \frac{N!}{B!(N-B)!} p^{N-B}(1-p)^B$

GOOD PART PROBABILITY

NUMBER OF BAD PARTS ON A BOARD

% OF BOARDS	.97	.98	.99	.999	.9999
0	21.8%	36.4%	60.5%	95.1%	99.5%
1	33.7%	37.2%	30.6%	4.8%	0.5%
2	25.6%	18.6%	7.6%	0.1%	
3	12.6%	6.1%	1.2%		
4	4.6%	1.5%	0.1%		
5	1.3%	0.2%			
6	0.3%				

FAILED PART DISTRIBUTIONS FOR A 50 PART BOARD

TABLE 2

GOOD PART PROBABILITY

	% OF BOARDS	.97	.98	.99	.999	.9999
	0	4.8%	13.3%	36.6%	90.5%	99.0%
	1	14.7%	27.1%	37.0%	9.1%	1.0%
NUMBER OF BAD PARTS ON A BOARD	2	22.5%	27.3%	18.5%	0.4%	
	3	22.7%	18.2%	6.1%		
	4	17.1%	9.0%	1.5%		
	5	10.1%	3.5%	0.3%		
	6	5.0%	1.1%			
	7	2.1%	0.3%			
	8	0.7%	0.1%			
	9	0.2%				

FAILED PART DISTRIBUTIONS FOR A

100 PART BOARD

TABLE 3

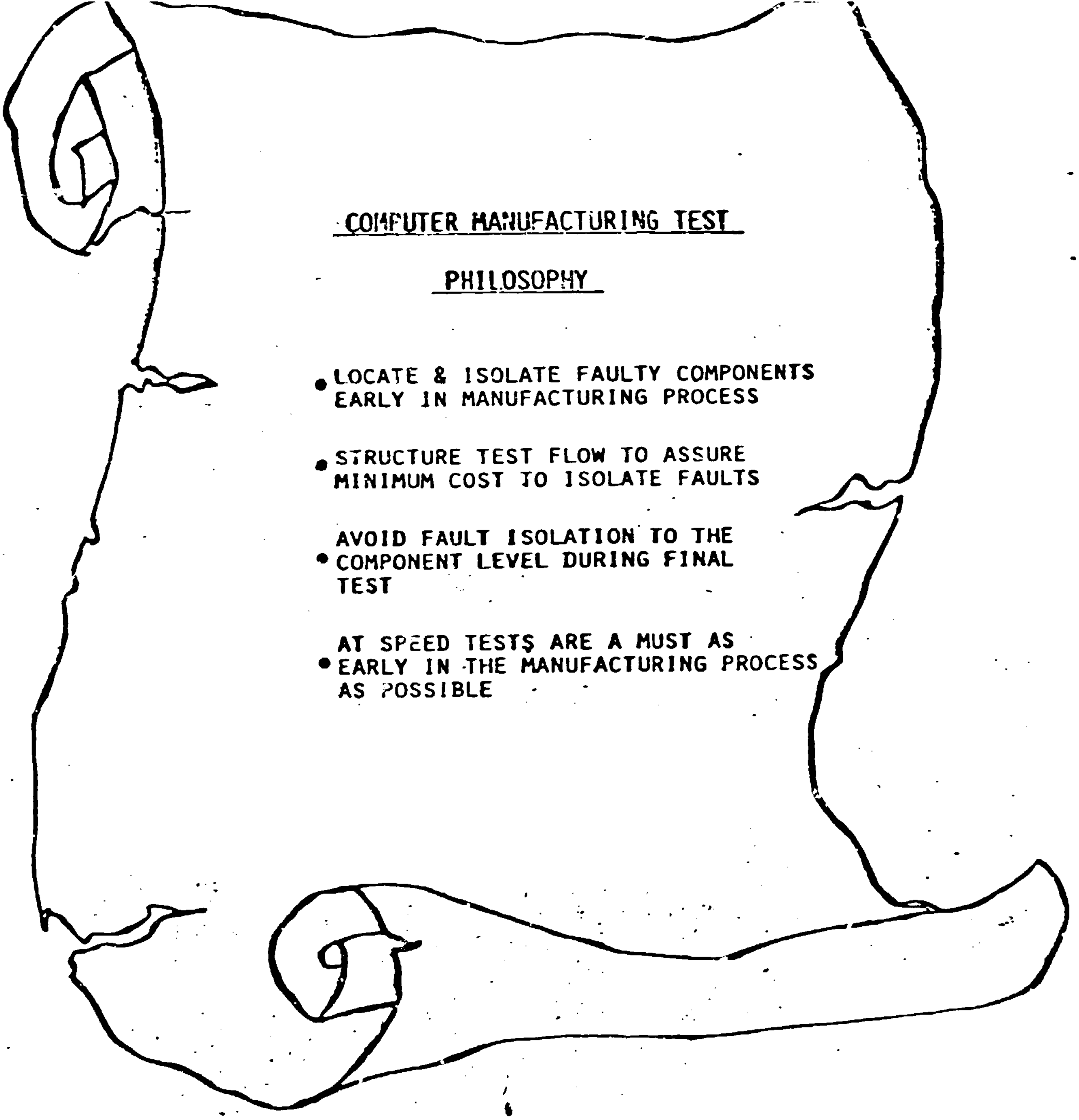
GOOD PART PROBABILITY

NUMBER OF BAD PARTS ON A BOARD

% OF BOARDS	.97	.98	.99	.999	.9999
0	0.23%	1.8%	13.4%	81.9%	98.0%
1	1.4%	7.2%	27.1%	16.4%	2.0%
2	4.3%	14.6%	27.2%	1.6%	
3	8.8%	19.6%	18.1%	0.1%	
4	13.4%	19.7%	9.0%		
5	16.2%	15.8%	3.6%		
6	16.3%	10.5%	1.2%		
7	14.0%	5.9%	0.3%		
8	10.4%	2.9%	0.1%		
9	6.9%	1.3%			
10	4.1%	0.5%			
11	2.2%	0.2%			
12	1.1%				
13	0.5%				
14	0.2%				
15	0.1%				

FAILED PART DISTRIBUTIONS FOR A
200 PART BOARD

TABLE 4

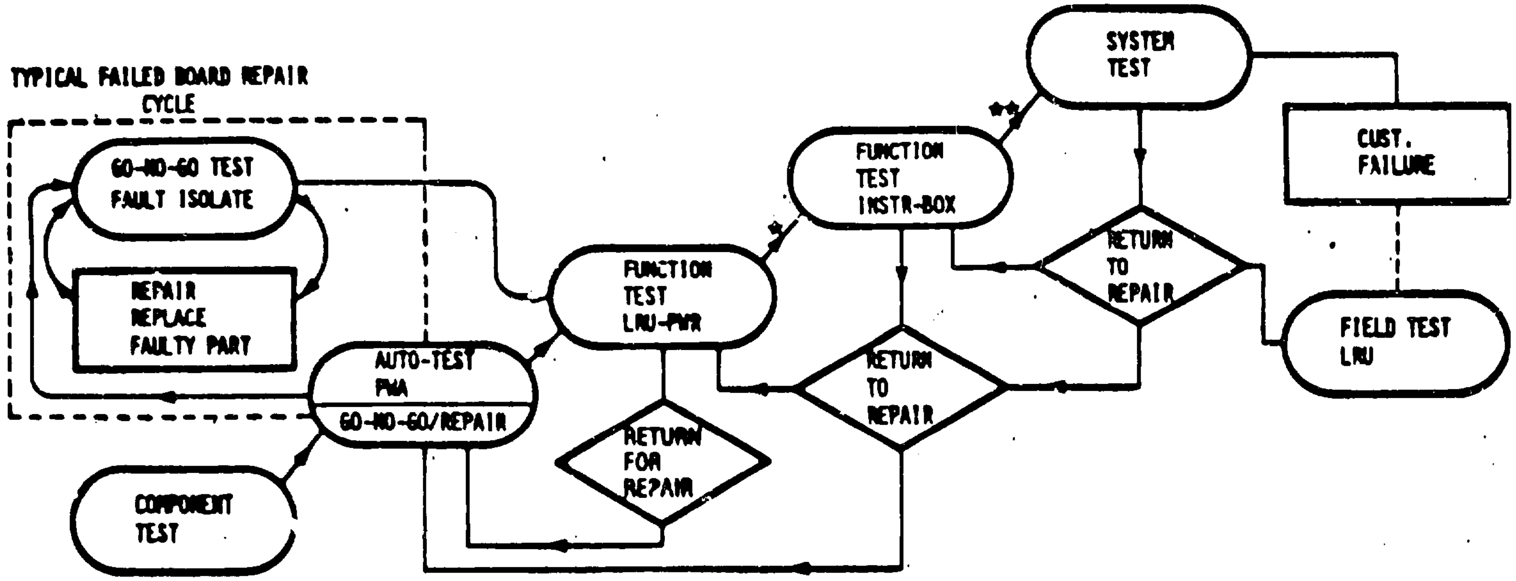


COMPUTER MANUFACTURING TEST

PHILOSOPHY

- LOCATE & ISOLATE FAULTY COMPONENTS EARLY IN MANUFACTURING PROCESS
- STRUCTURE TEST FLOW TO ASSURE MINIMUM COST TO ISOLATE FAULTS
- AVOID FAULT ISOLATION TO THE COMPONENT LEVEL DURING FINAL TEST
- AT SPEED TESTS ARE A MUST AS EARLY IN THE MANUFACTURING PROCESS AS POSSIBLE

ELECTRONIC TEST HIERARCHY/FAULT COST



COST TO FIND FAULT $.25	$2.50	$25.00	$40.00	$140.00	$600.00
USE [illegible] OR DYNAMIC/PARA	AUTO-TEST IN CIRCUIT COMPONENT	HOT BOX FIRST LEVEL DYNAMIC	COMPLETED ASSEMBLIES FINAL TEST	BOX USED IN COMPLETE SYS	

* OVEN 80° 96 HRS

** OVEN 40° 24 HRS

COMPONENT SCREENING PROPOSAL
RIFLE VS. SHOTGUN

1. AS A GENERAL RULE ALL PURCHASED PARTS (DIODES, IC'S, POWER SUPPLIES, ETC.) WILL BE SECOND SOURCED.

2. ALL DIGITAL IC'S WILL BE PROGRAMMED AND TESTED ON THE HP 5046B I/C TESTER. THOSE PARTS WITH ≤.05% FAILURE RATE WILL BE CANDIDATES FOR SAMPLE TESTING.

3. MATERIAL WILL BE RECORDED AND SUMMARIZED FOR EACH COMPONENT'S FAILURE, DEFECT, FAILURE RATE.

4. ANY DIGITAL PART WITH >1% FAILURE RATE WILL BE FLAGGED IMMEDIATELY FOR CORRECTION OR INVESTIGATION.

5. A CRITICAL PARTS LIST WILL BE CREATED TO REVEAL:
    - SINGLE SOURCE PARTS
    - HIGH FAILURE RATE PARTS
    - CLASSIFICATION OF COMPONENTS A, B, C
    - VENDOR PROBLEMS IE DELIVERY, QUALITY, ETC.

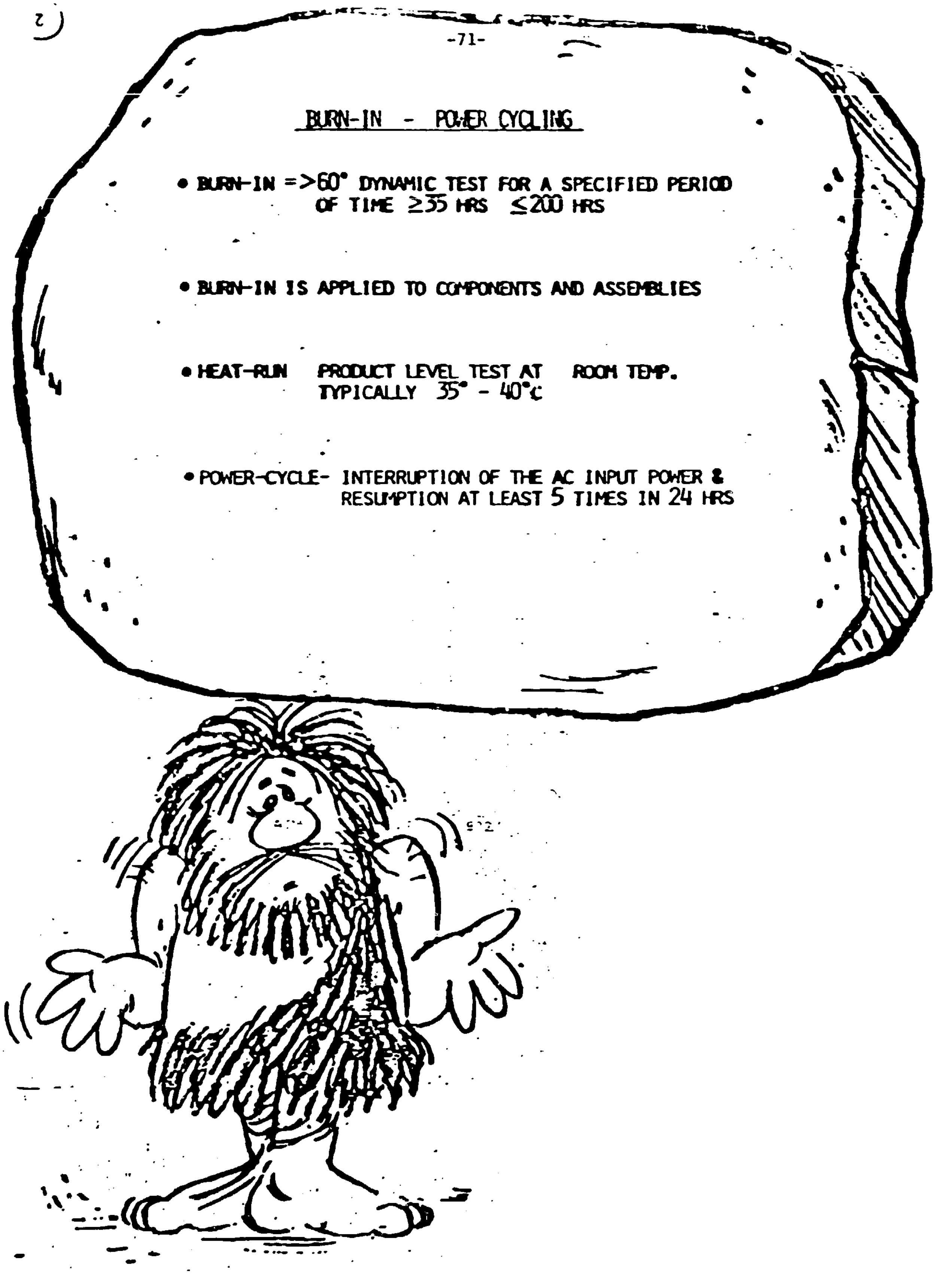
6. ALL MULTILAYER PC BOARDS WILL BE TESTED.

7. ALL MECHANICAL PARTS SPECIFIED WILL BE EXAMINED FOR TOLERANCE VARIANCE (USING GO-NO-GO GUAGES).

8. 64K RAMS WILL BE 100% PRETESTED & BURNED-IN PRIOR TO USE.

9. ALL PASSIVE COMPONENTS IE: RESISTORS, CAPACITORS ETC ARE SAMPLE TESTED (AQ2) @ 4%.

10. ALL ELECTRONIC ASSEMBLIES (PWR SUP DISKS) ARE 100% ELECTRICALLY TESTED UPON RECEIPT.



BURN-IN - POWER CYCLING

- BURN-IN =>60° DYNAMIC TEST FOR A SPECIFIED PERIOD OF TIME ≥35 HRS ≤200 HRS
- BURN-IN IS APPLIED TO COMPONENTS AND ASSEMBLIES
- HEAT-RUN PRODUCT LEVEL TEST AT ROOM TEMP. TYPICALLY 35° - 40°C
- POWER-CYCLE- INTERRUPTION OF THE AC INPUT POWER & RESUMPTION AT LEAST 5 TIMES IN 24 HRS

TYPICAL OPERATING CHARACTERISTIC CURVE

Probability of Acceptance Vs. True Percent Defective

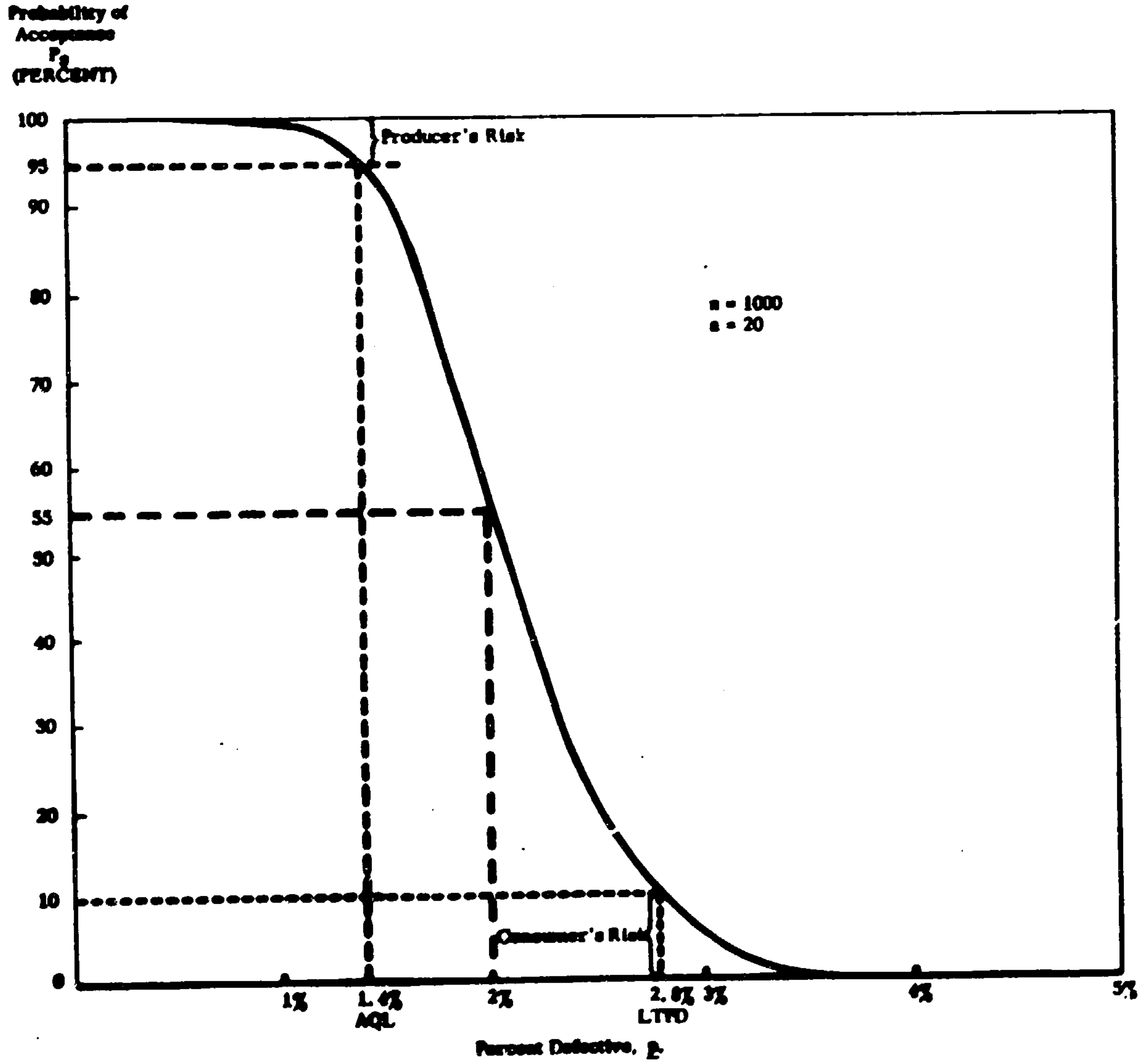
Chart showing probability, P_a, of accepting a lot drawn at random from a product of given quality, when:

- (a.) the true percent of defectives in the population is $\underline{p}$.
- (b.) the size of the sample, $\underline{n} = 1000$, is small compared to the size of the lot (less than 10%).
- (c.) the decision to accept or reject the lot is based on observing $\underline{c} = 20$ or fewer defects in the sample.

Examples: (a.) What is the probability of accepting a large size lot from which a sample of 1000 is to show no more than 20 defectives, when the true percent defective is 2%? Answer: $\underline{p} = 2\%$, $P_a = 55\%$.

(b.) What is the producer's risk associated with an AQL (acceptable quality level) of 1.4%? Answer: $\underline{p} = 1.4\%$.
Producer's Risk $= 1 - P_a = 1 - .95 = .05$

(c.) What is the consumer's risk associated with an LTPD (lot tolerance percent defective) of 2.8%? Answer: $\underline{p} = 2.8\%$.
Consumer's Risk $= P_a = .10$



PREPARED BY:

Reliability Research & Education Dept.
Reliability Division
AC Spark Plug Division
Milwaukee 1, Wisconsin

October 2, 1961

OPERATING CHARACTERISTIC CURVES

Probability of Acceptance Vs. True Percent Defective

Probability, P_a, of accepting a lot drawn at random from a product of given quality, when:

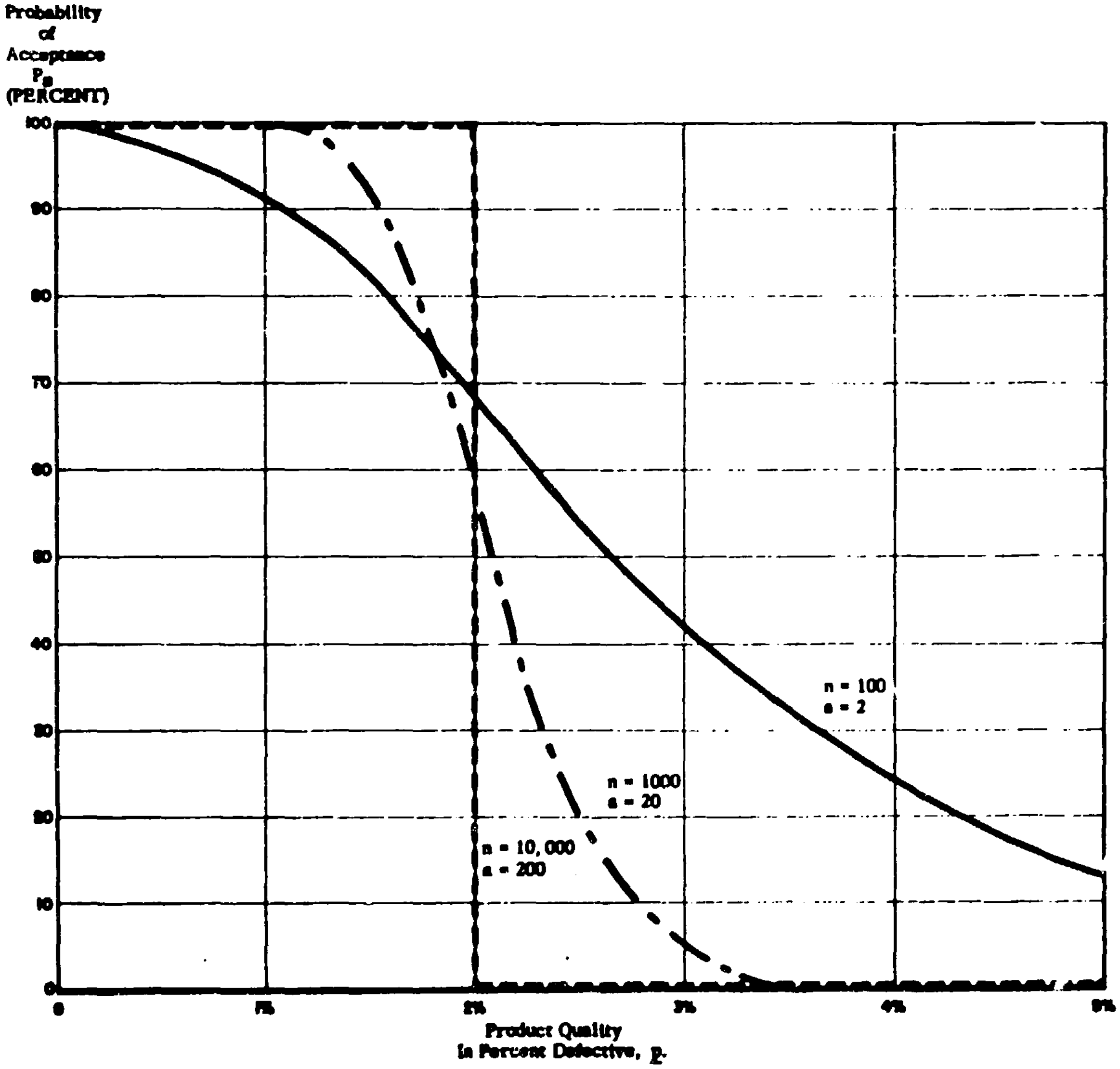
(a.) the true percent of defectives in the population is p.

(b.) the size of the sample is n.

(c.) the number of defectives in the sample is a or less.

Example: What is the probability that a product line with 3% defectives will yield samples of 100 with two or less failures?

Answer: $p = 3\%$. $n = 100$. $a = 2$. $P_a = 42\%$.



PREPARED BY:

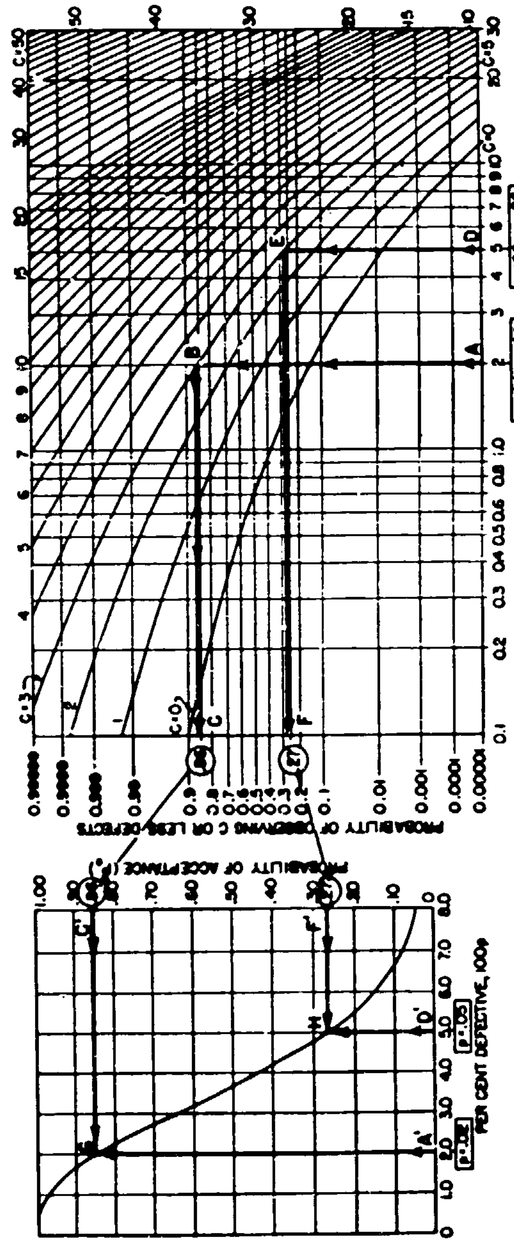
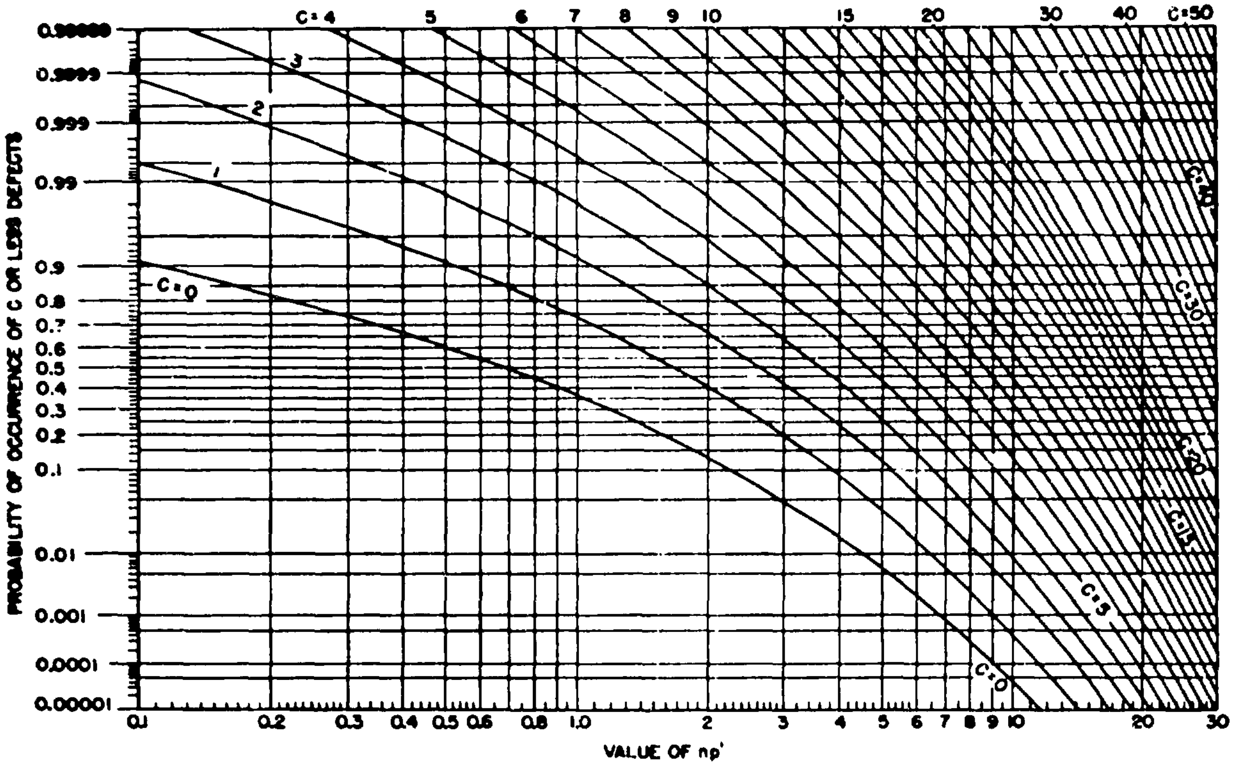


FIG. 17. Procedure for obtaining the operating-characteristic curve.

CHART K. POISSON CHART*



*Reproduced by permission from Dodge and Romig, "Sampling Inspection Tables," John Wiley & Sons, Inc., New York, 1944. For details of use see p. 425.

TEST METHODS

Method No.	
	Environmental tests
1001	Barometric pressure, reduced (altitude operation)
1002	Immersion
1003	Insulation resistance
1004.2	Moisture resistance
1005.2	Steady state life
1006	Intermittent life
1007	Agree life
1008.1	High-temperature storage
1009.2	Salt atmosphere (corrosion)
1010.2	Temperature cycling
1011.2	Thermal shock
1012	Thermal characteristics
1013	Dew point
1014.2	Seal
1015.2	Burn-in test
1016	Life/reliability characterization tests
1017	Neutron irradiation
1018	Internal water-vapor content
	Mechanical tests
2001.2	Constant acceleration
2002.2	Mechanical shock
2003.2	Solderability
2004.2	Lead integrity
2005.1	Vibration fatigue
2006.1	Vibration noise
2007.1	Vibration, variable frequency
2008.1	Visual and mechanical
2009.1	External visual
2010.3	Internal visual (monolithic)
2011.2	Bond strength
2012.2	Radiography
2013	Internal visual
2014	Internal visual and mechanical
2015.1	Resistance to solvents
2016	Physical dimensions
2017.1	Internal visual (hybrid)
2018	Scanning electron microscope (SEM) inspection of metallization
2019.1	Die shear strength
2020	Particle impact noise detection test
2021	Glassivation layer integrity
2022	Meniscograph solderability
	Electrical tests (digital)
3001.1	Drive source, dynamic
3002.1	Load conditions
3003.1	Delay measurements
3004.1	Transition time measurements
3005.1	Power supply current
3006.1	High level output voltage
3007.1	Low level output voltage
3008.1	Breakdown voltage, input or output
3009.1	Input current, low level
3010.1	Input current, high level
3011.1	Output short circuit current
3012.1	Terminal capacitance
3013.1	Noise margin measurements for digital microelectronic devices
3014	Functional testing

TEST METHODS - Continued

Method No.	
	Electrical tests (linear)
4001	Input offset voltage and current and bias current
4002	Phase margin and slew rate measurements
4003	Common mode input voltage range Common mode rejection ratio Supply voltage rejection ratio
4004	Open loop performance
4005	Output performance
4006	Power gain and noise figure
4007	Automatic gain control range
	Test procedures
5001	Parameter mean value control
5002	Parameter distribution control
5003	Failure analysis procedures for microcircuits
5004.4	Screening procedures
5005.4	Qualification and quality conformance procedures
5006	Limit testing
5007.1	Wafer lot acceptance
5008	Test procedures for hybrid and multichip microcircuits

Rotary (wafer):

TABLE 5.1.11-3. **Prediction Procedure for Rotary Switches**

Part specification covered	Description
MIL-S-3786	Rotary, ceramic or glass wafer, silver alloy contacts

Part operating failure rate model (λp)

$$\lambda_p = \lambda_b (\pi_E \times \pi_{cyc} \times \pi_L) \text{ failures}/10^6 \text{ hours}$$

where factors are shown in:

π_E - Table 5.1.11-4

π_{cyc} - Table 5.1.11-6

π_L - Table 5.1.11-7

Base failure rate model (λ_b)

$\lambda_b = \lambda_{bE} + n\,\lambda_{bF}$ (for ceramic RF wafers)

$\lambda_b = \lambda_{bE} + n\,\lambda_{bG}$ (for rotary switch medium power wafers)

where n is the number of active contacts

Description	MIL-SPEC	Lower Quality
λ_{bE}	0.0067	0.1
λ_{bF}	0.00003	0.02
λ_{bG}	0.00003	0.06

TABLE 5.1.11-4

Environmental Mode Factors

Environment	π_E
G_B	1
S_F	1
G_F	2.9
N_{SB}	7.9
N_S	7.9
A_{IT}	5
M_P	21
M_{FF}	21
M_{FA}	29
G_M	14
N_H	32
N_{UU}	34
A_{UT}	50
N_U	20
A_{IF}	10
A_{RW}	46
U_{SL}	63
A_{UF}	100
M_L	71
C_L	1200

TABLE 5.1.11-5. π_C Factor for Contact Form and Quantity

Contact Form	π_C
SPST	1.0
DPST	1.5
SPDT	1.75
3PST	2.0
4PST	2.5
DPDT	3.0
3PDT	4.25
4PDT	5.5
6PDT	8.0

TABLE 5.1.11-6. π_{cyc} Factor for Cycling Rates

Switching Cycles per Hour	π_{cyc}
$\leq$ 1 cycle/hour	1.0
> 1 cycle/hour	number of cycles/hour

TABLE 5.1.11-7. π_L Stress Factor for Switch Contacts

Stress S	Load Type		
	Resistive	Inductive	Lamp
0.05	1.00	1.02	1.06
0.1	1.02	1.06	1.28
0.2	1.06	1.28	2.72
0.3	1.15	1.76	9.49
0.4	1.28	2.72	54.6
0.5	1.48	4.77	
0.6	1.76	9.49	
0.7	2.15	21.4	
0.8	2.72		
0.9	3.55		
1.0	4.77		

where $S = \dfrac{\text{operating load current}}{\text{rated resistive load}}$

$$\pi_L = e^{(S/.8)^2} \text{ for resistive.}$$

$$= e^{(S/.4)^2} \text{ for inductive.}$$

$$= e^{(S/.2)^2} \text{ for lamp.}$$

Example 1

Given: A MIL-SPEC toggle switch is used in a ground fixed environment. The switch is a snap-action switch and is single-pole, double-throw. It is operated on the average of one cycle per hour, and load current is 50 percent of rated and is resistive.

Find: The failure rate of the switch.

Step 1. The base failure rate λ_b is found in Tbl 5.1.11-1 and is determined to be 0.00045 failures/10^6 hours.

Step 2. The environmental factor π_E for ground fixed environment is determined from Table 5.1.11-4 to be 2.9.

Step 3. The contact form factor π_C is determined from Tbl 5.1.11-5 For a single-pole, double-throw switch, π_C is 1.75.

Step 4. The cycling factor π_{cyc} is determined from Tbl 5.1.11-6 to be equal to 1.0.

Step 5. The stress factor π_L from 5.1.11-7 for 50 percent stress factor and a resistive load is determined to be 1.48.

Step 6. The failure rate mathematical model for toggle switches is:

$$\lambda_p = \lambda_b (\pi_E \times \pi_C \times \pi_{cyc} \times \pi_L)$$

Substituting for these factors:

$$\lambda_p = 0.00045 (2.9 \times 1.75 \times 1.0 \times 1.48)$$

$$\lambda_p = 0.0034 \text{ failures}/10^6 \text{ hours.}$$

Example 2

Given: A MIL-SPEC rotary switch is installed in an airborne inhabited, transport environment. It has a medium power wafer, one deck, and six contacts. The switch is cycled an average of 5 cycles per hour, and the load current is 50 percent of rated current and is resistive.

Find: The failure rate of the switch.

Step 1. The base failure rate λ_b is determined from Table 5.1.11-3.

$$\lambda_b = \lambda_{bE} + n\ \lambda_{bG}$$

Substituting the values from Table 5.1.11-3

$$\lambda_b = 0.0067 + 6\ (0.00003)$$

$$\lambda_b = 0.00688 \text{ failures}/10^6 \text{ hours.}$$

Step 2. The environmental factor for airborne inhabited, transport (π_E) is determined from Table 5.1.11-4 to be 5.0.

Step 3. The cycling factor π_{cyc} is determined from Tbl 5.1.11-6 to be 5.0.

Step 4. The stress factor π_L is determined from Tbl 5.1.11-7 to be 1.48.

Step 5. The failure rate mathematical model for rotary switches is:

$$\lambda_p = \lambda_b\ (\pi_E \times \pi_{cyc} \times \pi_L)$$

Substituting values determined in the formula:

$$\lambda_p = 0.00688\ (5.0 \times 5.0 \times 1.48)$$

$$\lambda_p = 0.255 \text{ failures}/10^6 \text{ hours.}$$

CONTENTS

Paragraph		Page
1.	SCOPE	1
1.1	Scope	1
1.2	Application	1
1.2.1	Alternative applications	1
1.3	Classification	1
1.4	Relationship to total reliability program	1
2.	APPLICABLE DOCUMENTS	2
2.1	Issues pf documents	2
2.2	Other publications	2
3.	DEFINITIONS	3
4.	GENERAL REQUIREMENTS	6
4.1	General	6
4.1.1	First article (preproduction) reliability qualification test	6
4.1.2	Production reliability acceptance test (sampling)	6
4.1.3	All equipment production reliability acceptance test	6
4.2	Reliability test planning	6
4.2.1	Integrated test planning	6
4.2.2	Reliability test plan document	6
4.2.3	Reliability test procedures	6
4.3	Test conditions/levels	6
4.3.1	Definition of test conditions	6
4.3.2	Combined environmental conditions/stresses	7
4.3.2.1	Electrical stress	7
4.3.2.2	Vibration stress	7
4.3.2.3	Thermal stress	7
4.3.2.4	Moisture stress	7
4.3.2.5	Procedures for deriving test conditions	7
4.4	Optional non-statistical production reliability acceptance test (sequential environment)	11
4.4.1	Option I	11
4.4.2	Option II	11
4.5	Statistical test plans (APPENDIX C)	11
4.5.1	General	11
4.5.1.1	Standard test plans	11
4.5.1.2	Operating characteristic and expected test time curves	11
4.5.2	Requirements	11
4.5.2.1	Selection of test plan	11
4.5.2.2	Equipment performance	14
4.5.2.3	Equipment quantity	14
4.5.2.4	Test length	14
4.5.2.5	Evaluation criteria	14
4.5.3	Sequential test plans	14
4.5.4	Test Plan XVIIIC-Example (all equipment production reliability acceptance)	14
4.5.4.1	Test duration	15
4.5.4.2	Evaluation	15
4.5.4.3	Reject-accept criteria for Test Plan XVIIIC	15
4.5.4.3.1	Acceptance	15
4.5.4.3.2	Rejection	15
4.5.4.3.3	Reaching the boundary line	15
4.5.4.3.4	Alternative all-equipment production reliability acceptance test plans	15

CONTENTS (Continued)

Paragraph		Page
4.6	MTBF estimation from observed test data	15
4.6.1	Exclusion of hypothesis test values	18
4.6.2	Specified confidence interval	18
4.6.3	MTBF estimation from fixed-length test plans	18
4.6.4	Projection of expected field MTBF	21
5.	DETAILED REQUIREMENTS	23
5.1	Conditions preceding the reliability qualification test	23
5.1.1	Reliability prediction	23
5.1.2	Reliability test plan document	23
5.1.3	Reliability test procedures	23
5.1.4	Reliability test plan and procedures	23
5.1.5	Thermal survey	23
5.1.6	Vibration survey	23
5.1.7	Test unit configuration	23
5.1.8	Pretest readiness review	24
5.1.9	Preconditioning burn-in	24
5.2	Inspection and surveillance	24
5.3	Equipment test cycle	24
5.4	Test facilities	24
5.4.1	Calibration	24
5.5	Test implementation	25
5.5.1	Selection of equipment	25
5.5.1.1	Reliability first article (preproduction) qualification test	25
5.5.1.2	Reliability production acceptance test	25
5.5.2	Installation of equipment	25
5.5.3	Measurement	25
5.5.4	Testing sequence	25
5.6	Failure actions	25
5.6.1	Failure categories	26
5.6.1.1	Relevant failures	26
5.6.1.2	Nonrelevant failures	26
5.6.1.3	Chargeable failures	26
5.6.1.4	Nonchargeable failures	26
5.6.2	Analysis of failures	27
5.7	Determination of compliance	27
5.7.1	General	27
5.7.2	Accept in reliability qualification phase	27
5.7.3	Accept in production reliability acceptance phase	27
5.7.3.1	Production lot sampling test	27
5.7.3.2	All equipment reliability test	27
5.7.4	Reject in reliability qualification phase	27
5.7.5	Reject in reliability production acceptance phase	27
5.7.5.1	Production lot sampling test	27
5.7.5.2	All equipment reliability test	28
5.8	Verifying repair	28
5.9	Corrective action	28
5.10	Preventive maintenance	28
5.11	Restoration of tested equipments	28
5.12	Test records	28
5.13	Reliability test reports	28
5.13.1	Periodic summary	28
5.13.2	Final report	28
5.13.2.1	Failure summary and analysis	28
5.13.2.2	General reliability analysis of equipment	29

3. DEFINITIONS

3.1 General. Meanings of terms not defined herein are in accordance with the definitions in MIL-STD-721.

3.1.1 Contractor. Contractor includes Government or industrial activities developing/producing military systems and equipments.

3.1.2 Decision risks.

3.1.2.1 Consumer's risk (β). Consumer's risk (β) is the probability of accepting equipment(s) with a true MTBF equal to the lower test MTBF (θ_1). (The probability of accepting equipment(s) with true MTBF less than the lower test MTBF (θ_1) will be less than β.)

3.1.2.2 Producer's risk (α). Producer's risk (α) is the probability of rejecting equipment(s) with a true MTBF equal to the upper test MTBF (θ_0). (The probability of rejecting equipment(s) with true MTBF greater than the upper test MTBF will be less than α.)

3.1.2.3 Discrimination ratio (d). The discrimination ratio is one of the standard test plan parameters which establishes the test plan envelope. This ratio discriminates between θ_1 and θ_0.

$$d = \frac{\theta_0}{\theta_1}$$

3.1.3 Failure. Details involving failure criteria, to include required functions and performance parameter limits, must be stated in the equipment specification and test procedures as approved by the procuring activity. For test purposes, the following general definitions shall apply:

a. Failure is an event in which a previously acceptable item does not perform one or more of its required functions within the specified limits under specified conditions.
b. Failure is also the condition in which a mechanical or structural part or component of an item is found to be broken, fractured, or damaged which would cause failure under operational conditions.

3.1.4 Failure types.

3.1.4.1 Dependent failure. A failure caused by the failure of an associated item (dependent failures are not necessarily present when simultaneous failures occur).

3.1.4.2 Independent failure. A failure which occurs without being caused by the failure of other parts of the equipment under test, test equipment, instrumentation, or the test facility.

3.1.4.3 Intermittent failure. The momentary cessation of equipment operation.

3.1.4.4 Multiple failures. The simultaneous occurrence of two or more independent failures (when two or more failed parts are found during trouble shooting which cannot be shown to be interdependent, multiple failures are presumed to have occurred).

3.1.4.5 Pattern failures. The occurrence of two or more failures of the same part in identical or equivalent application which are caused by the same basic failure mechanism.

3.1.5 Failure classification. All failures are relevant and chargeable unless and until determined to be nonrelevant or nonchargeable or both by the procuring activity.

3.1.5.1 Relevant failure. All failures that can be expected to occur in subsequent field service. All relevant failures shall be used in computation of demonstrated MTBF.

3.1.5.2 Nonrelevant failure. A failure caused by a condition external to the equipment under test which is not a test requirement and not expected to be encountered in field service.

3.1.5.3 Chargeable failure. A relevant, independent failure of Contractor Furnished Equipment (CFE) under test, plus any dependent failures caused thereby, classified as one failure and used to determine contractual compliance with accept/reject criteria.

3.1.5.4 Nonchargeable failure. A relevant failure of CFE, caused by and dependent upon an independent failure of Government Furnished Equipment (GFE) or CFE of another contractor, and therefore not used to determine contractual compliance with accept/reject criteria.

3.1.5.5 Equipment design (ED). Failure in this area places the cause directly upon the design of the equipment; that is, the design of the equipment caused the part in question to degrade or fail, resulting in an equipment failure; for example, a circuit design which overstresses a part or other improper application of parts.

3.1.5.6 Equipment manufacturing (EM). These failures are caused by poor workmanship during the equipment construction, testing, or repair prior to start of test. This would also include possible overstressing of parts by the assembly process during the construction of the equipment.

3.1.5.7 Part design (PD). This category of failures consists of parts whose failures resulted directly from the inadequate design of the part. This would include such areas as the longevity of the part and its ability to withstand continuous temperature cycling.

3.1.5.8 Part manufacturing (PM). These failures are the result of poor workmanship during assembly of the part, inadequate inspection or testing.

3.1.5.9 Software errors (SE). These errors cause equipment failures when a computer was part of the equipment under test. NOTE: If software errors are corrected and verified during the test, such errors shall not be chargeable as equipment failures.

3.1.6 Mean-time-between-failures (MTBF).

3.1.6.1 Demonstrated MTBF ($\bar{\theta}$). The probable range of true MTBF under test conditions; observed MTBF within a stated confidence interval.

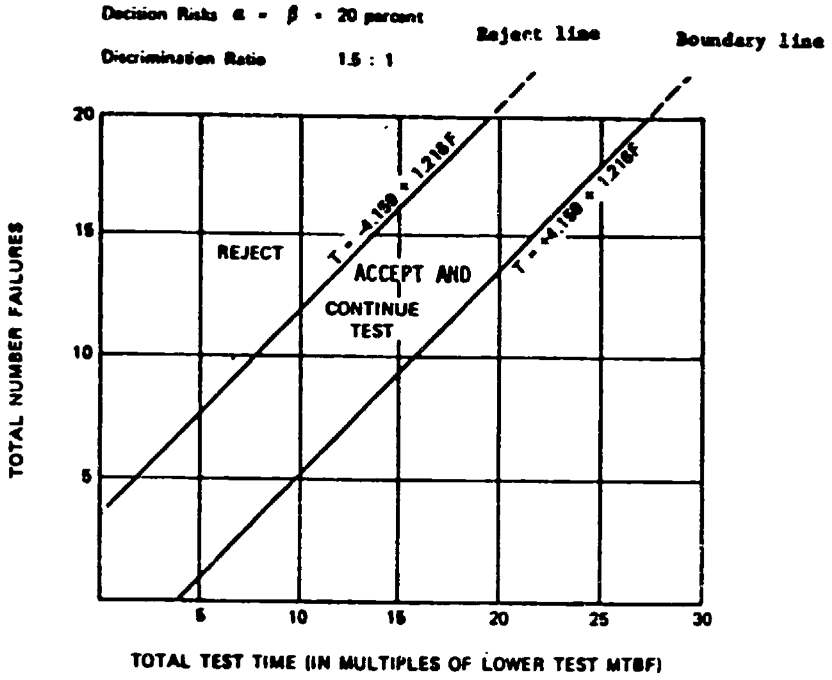
3.1.6.2 Observed MTBF ($\hat{\theta}$). Observed MTBF ($\hat{\theta}$) is equal to the total operating time of the equipment divided by the number of relevant failures.

3.1.6.3 Lower test MTBF (θ_1). Lower test MTBF (θ_1) is that value which is unacceptable and the standard test plans will reject, with high probability, equipment with a true MTBF that approaches θ_1 (θ_1 is equivalent to noncompliance with reliability requirements and will be included in Section 4 of the equipment specifications).

3.1.6.4 Upper test MTBF (θ_o). Upper test MTBF (θ_o) is an acceptable value of MTBF equal to the discrimination ratio times the lower test MTBF (θ_1). The standard test plans will accept, with high probability, equipment with a true MTBF that approaches θ_o (both θ_o and θ_1 should be identified in Section 3 of the equipment specifications).

3.1.6.5 Predicted MTBF (θ_p). Predicted MTBF (θ_p) is that value of MTBF determined by reliability prediction methods and is based on the equipment design and the use environment (θ_p should approach θ_o in value to ensure with high probability that the equipment will be accepted during the reliability qualification test).

3.1.7 Mission profile. A mission profile is a thorough description of all of the major planned events and conditions associated with one specific mission. As such, a mission profile is one segment of a life profile (for example, a missile captive carry phase, or a missile free flight phase). The profile will depict the time span of the event, the expected environmental conditions, energized and non-energized periods, and so forth.



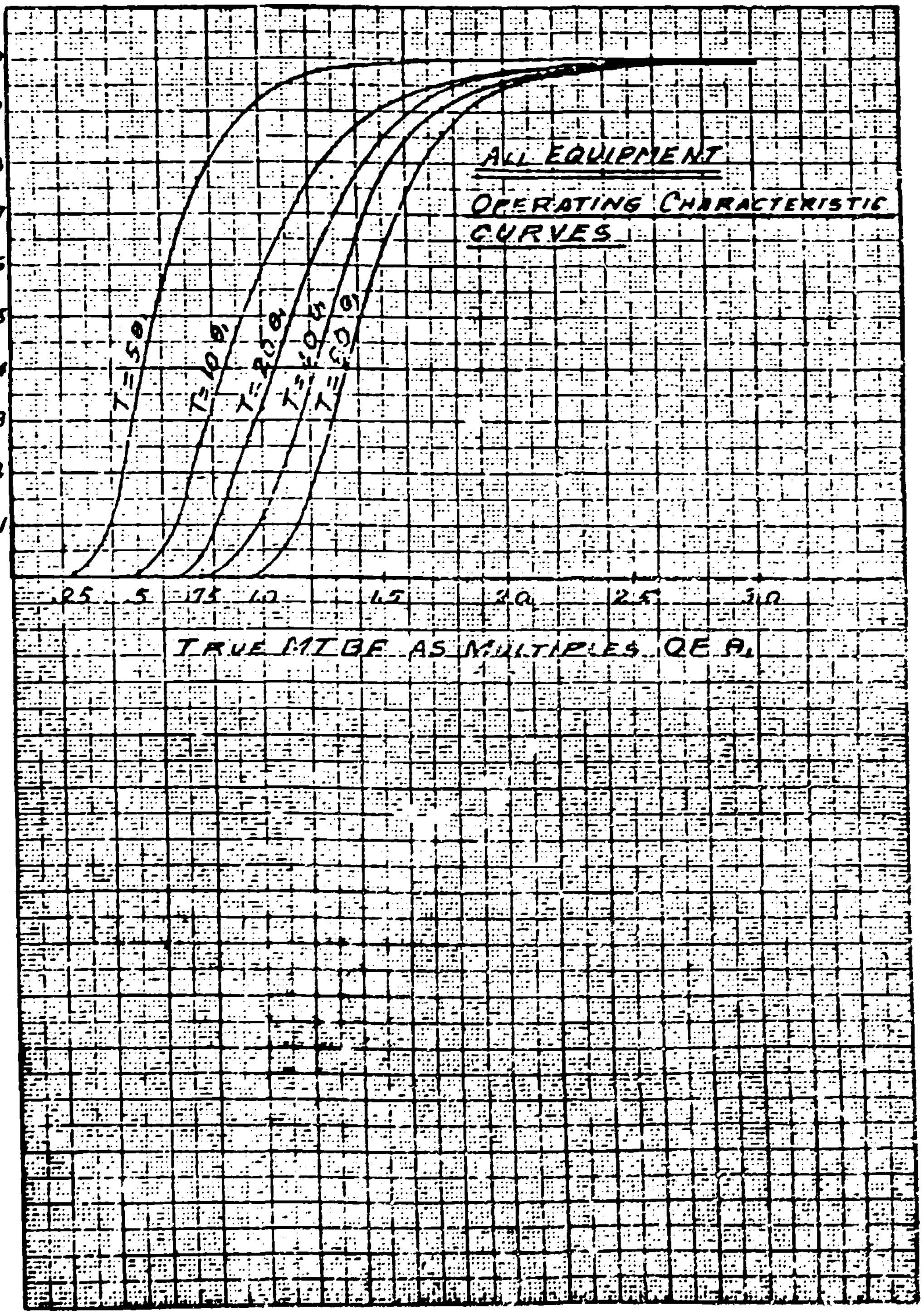
Number of Failures	Total Test Time* Reject (Equal or less)	Total Test Time* Accept (Equal or more)
0	N/A	4.16
1	N/A	5.38
2	N/A	6.59
3	N/A	7.81
4	0.70[illegible]	9.02
5	1.92	10.24
6	3.14	11.46
7	4.35	12.67
8	5.57	13.89
9	6.78	15.10

Number of Failures	Total Test Time* Reject (Equal or less)	Total Test Time* Accept (Equal or more)
10	8.0	16.32
11	9.22	17.54
12	10.43	18.75
13	11.65	19.97
14	12.87	21.18
15	14.08	22.40
16	15.29	23.62
17	16.51	24.83
18	17.73	26.03
19	18.96	27.26

* Total test time is total unit hours of equipment on time and is expressed in multiples of the lower test MTBF. Refer to 4.5.4.1 for minimum test time per equipment.

FIGURE C-11. Accept-reject criteria derived from Test Plan IIC.

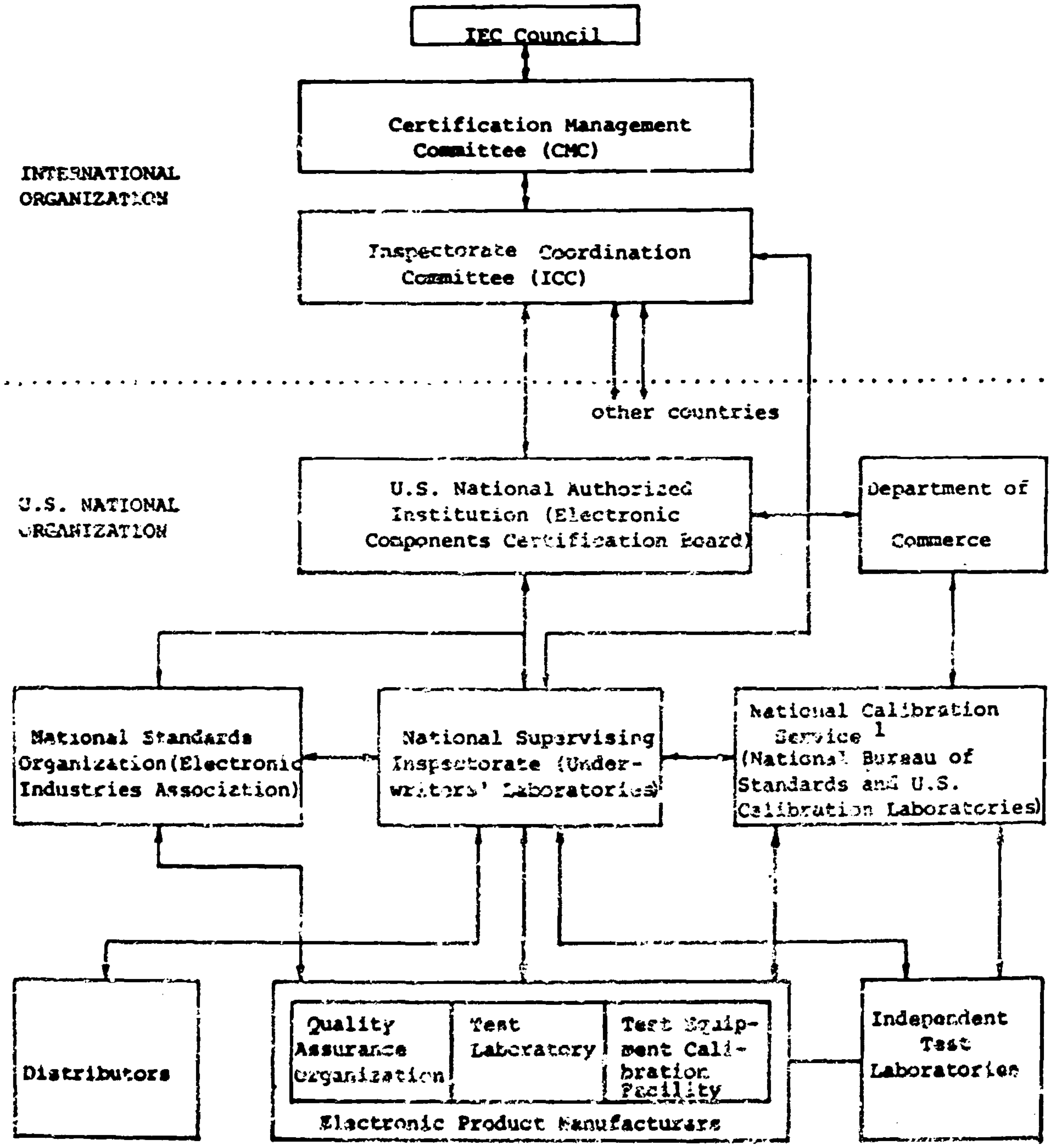
CHART 23 DERIVED FROM TEST PLAN II C



D RELIABILITY TEST PROCEDURES
E TEST INSTRUMENTATION AND FACILITIES

FIGURE 1

THE U.S. NATIONAL ORGANIZATION IECQ-SYSTEM ORGANIZATIONAL TREE



Note 1: The National Calibration Service is the U.S. National Bureau of Standards operating in conjunction with a U.S. network of calibration laboratories.