IEEE

RELIABILITY GROUP NEWSLETTER

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Editor: Naomi J. McAfee

Editor's Notes

This is the last issue of the Newsletter to be published under my direction. In some ways it has been an interesting two plus years and in another it has only confirmed some of the things I already knew, i.e., people will accomplish many things but to describe these achievements in writing is too great a sacrifice.

The Annual Reliability and Maintainability Symposium's Board of Directors recently made a decision to no longer allow its co- sponsors to present awards at the Symposium Banquet. The reason cited was that there are now too many co-sponsors and too much time is used in the presentation and acceptance of such awards. However, at the 1977 Symposium one of the sponsors presented its annual ward to a woman (a first for the Symposium). Is there a relationship? It makes one wonder!

The new editor at this time is nameless. You will be meeting him in the April issue of the Newletter. Please give him your support in any way possible.

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Chapter News

Baltimore

The Baltimore Chapter will hold its next meeting February 21, 1978 at the Beltway Inn. Mr. Leroy Resser, Isotopes, Inc. will be the speaker. The April 18, 1978 meeting will be a joint meeting with the Washington/Northern Virginia Chapter. Ms. Naomi McAfee, Westinghouse Electric Corporation, will discuss "The Quality/Reliability Interface."

Boston

In September Lt. Col. Fred Nohmer (USAF) delivered an interesting presentation on the RIW aspects of the TACAN Program to 40 attendees, and in October/November Don Fradette of Raytheon conducted a 5-week lecture series on "Mathematical Techniques for Reliability." Thirty-five people attended this lecture series.

On December 14, 1977, Mr. Bob Hovious of Sanders Associates discussed "A Manager's Look At Reliability."

January 18, 1978, Mr. A. Minicello, Raytheon will discuss "LCC/DTC." February 15,1978, Mr. E. Carruba, GTE Sylvania will present "Reliability Specs Revisited," and the final meeting will be March 15, 1978. All meetings will be held at the Officers Club, Hanscom Field.

The year will be ended as usual with an all-day seminar on April 27, 1978. This year's theme will be "Exploring the Assurance Sciences."

Chicago

"Successful Reliability Seminar Conducted for 40 Engineers in Chicago Chapter"

The 2nd Annual Tutorial Reliability Program was conducted on November 12, 1977 and featured a broad range of reliability criteria relating to the electronics, electric, and solar industries.

Slides, over-heads, and 16mm films were shown by five instructors to project the reliability statistics and formula needed to plan a reliable system.

New to the program this year was Utility Power Considerations and Solar Power Considerations.

The featured speakers and topics were:

Hugh Edfors — Gard, Inc.
Reliability Basics, Maintainability and a Reliability Film by USN entitled "Basic Reliability Concepts"

Henry Malec — GTE Automatic Electric Labs
Reliability Modeling and Cost Effectiveness

Ray Schirmer — ITT, Telecommunications
Derating

Stan Anderson — Commonwealth Edison
Utility Power Reliability Considerations

Paul Clawson — KGA Engineering Co., Inc.
Solar Power Considerations

Other chapter activities included a tour of the Underwriters Laboratories in Northbrook, Illinois in October. Tour guide R. Yerke from U.L. explained the different departments which included: explosion devices, air conditioning and heating, smoke detectors, fire control and sprinkler systems, roofing, insulation, and fire proofing.

Coming events will include Thomas C.B. Ayres of DeLeuw, Cather & Co., speaking on Mechanical Reliability in February 1978, and in April 1978 Mr. Hugh Edfors of Gard, Inc. will present a panel session on the Reliability of Magnetic Bubble Memories.

Time and place of both will be announced at a later date.

New York/Long Island

The Long Island and Metropolitan New York Chapter have been integrated into one Reliabililty Chapter known as the "New York/Long Island Chapter."

The officers for the 1977-1978 year are:

Chairman:	Joseph Drvostep Grumman Aerospace Corporation
Vice-Chairman:	Hank D. Wolf Grumman Aerospace Corporation
Vice-Chairman:	Harvey Berman Underwriters Labs, Inc.

Our program for this year is as follows:

At the first meeting on September 20, Mr. Robert H. Gauger, Supervisor of Reliability Services, Holmes & Narver Inc., presented some interesting facts about Nuclear Energy, and described the extent to which other energy sources can be expected to meet our requirements by the year 2000.

On November 15, Mr. Dan Patton, Chief of the Division of Environmental Assessment of the New York Outer Continental Shelf Office spoke on the "Risks Associated with Outer Continental Shelf Exploration and Production Operations." Exploration, development, and production operations encounter many geological and meteorological hazards, which along with equipment failure and human error can lead to blowouts of exploratory wells, damage to production platforms, spills from pipelines and tankers, as well as loss of human life.

Meetings planned for next year include:

March	An updated report of experience encountered by Pan Am in the procurement and maintenance of avionics equipment with reliability and maintainability warranties.
April	A tour of the expanded and modernized Underwriters Laboratories facility at Melville, Long Island.

Philadelphia

The first meeting of the year was held October 18, 1977. The speaker was Mr. Charles R. Heising, General Electric Company, who discussed "Reliability Versus Cost Studies of Industrial and Commercial Power Systems."

Washington/Northern Virginia

The November meeting featured a talk by Mr. Cal Dicks of General Electric entitled "Reliability Analysis Applied to Mechanical and Structural Systems." Areas of discussion included problems encountered during reliability analysis of these systems, design and analysis techniques and their relationship to reliability, and selected reliability disciplines which may be effectively implemented to enhance the reliability of mechanical and structural systems.

Mr. Dicks is a senior systems engineer with the General Electric Company currently providing engineering services to the Naval Air Systems Command. His experience in reliability includes reliability analysis, requirements specifications, management and control documentation, and other related areas. His background in mechanical and structural systems includes stress/strength analysis and testing of aircraft and missiles. He has authored papers on Structural Reliability.

Other meetings are scheduled as follows:

11 Jan 1978	Reliability and Maintainability Influence on System Life Cycle Costs
Speaker	William Wagner, Teledyne CAE
Location	Ramada Inn 8400 Wisconsin Ave. Bethesda, Md.
15 Feb 1978	Unique Approach to Reliabililty in AEGIS System Design
Speaker	Nick Lutz, Bird Associates
Location	Ramada Inn
16 Mar 1978	Good Laboratory Practices (joint meeting with ASQC)
Speaker	Nat Geary, FDA
19 Apr 1978	Quality/Reliability Interface (joint meeting with ASQC Baltimore Chapter)
Speaker	Naomi J. McAfee, Westinghouse Electric Corporation
17 May 1978	Open

Letter To The Editor

Dear Editor:

Notes on Reliability Testing for Industry Use:

1. Good article by W.T. Greenwood, Jr.

2. On Cerdip packages, two considerations are most important:

   2.1 Gross leak testing after burn-in and test handling. Cerdip typically has 1 to 2 percent breakage during handling in these burn-in tests.

   2.2 Based on recent industry testing, including STC, Epoxy B or Novalac type packages are showing better (lower) failure rates than Cerdip, both early life and long term.

3. On epoxy and Cerdip devices, temperature cycling is a very cost effective screen. Temperature cycling costs are 0 to 2 cents per device, depending on quantity. Commercial devices such as PEPI and Epoxy B+ have this temperature cycling and some tight electrical parameter testing. In any case, temperature cycling should be a part of any burn-in screen program and will result in even better early life performance.

Sincerely,

J.R. Adams
Manager of Component Technology
Storage Technology Corp.

Military Specifications: Friend or Foe?

by
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The designer may believe that mil specs and related documents exist only to assure a certain level of quality and performance in government contract work. While that is part of their purpose, the system of military documents actually has three main objectives:

- Provide standardization (minimum physical and performance specs) for thousands of materials, components, and systems commonly used in military systems.
- Provide documentation needed by those designing and inspecting to military specifications.
- Aid in the procurement of the billions of dollars worth of materials, components, and systems purchased for military use.

With the ever-increasing demand for new designs, there is a multitude of available materials, components, and systems for military and federal applications. But each manufacturer is independent. They have their own procedures, their own technology, and their own budget requirements. Consequently, there are a variety of solutions to one problem and numerous ways to develop a design. A method of standardization is needed to aid in communication, to minimize development and production time, to reduce cost and eliminate duplication - the reason that military and federal specifications and standards exist. They define the essential criteria to achieve uniformity in government purchased products and interchangeability of parts within these products. Standards and specifications define sampling, inspection, and test procedures used to determine that requirements have been met. They also ensure that government purchased items are suitable for their intended use at the maximum value of every dollar expended.

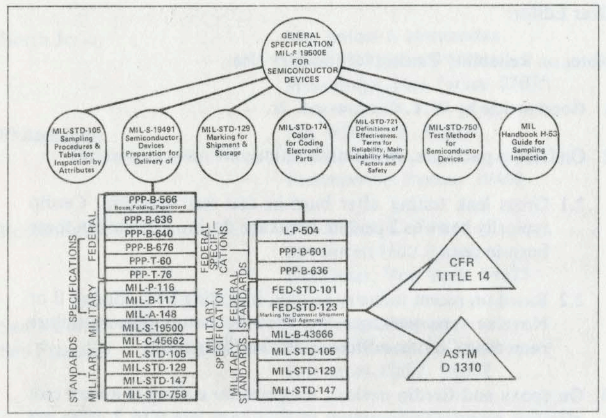

Figure 1

Disregarding the Qualified Products List (QPL) early in the design phase could be another costly situation. The trend of miniaturization, high performance, and greater reliability normally causes designers to use new technology. Consequently, specifications and qualified parts can be easily overlooked in the initial planning stage of the project. Unfortunately, government specifications and QPLs are not updated every time a new component is introduced on the market. All parts, however, must comply with the contract. Even if a component out-performs a similar one defined by mil spec, this component still must qualify in accordance to the contract. If the part is not on the QPL, PIL (preferred items list), or other appropriate lists, then there must be a choice between processing a "nonstandard" item for approval or applying for a waiver. After the award of contract, a parts evaluation program should be immediately initiated giving the following priority to each item: qualified preferred part, industrial standard part (EIA, NEMA, etc), and high-quality commercial part. This program will help determine which parts will be acceptable without further action and which ones require special testing, and in some cases, waiver.

It's not uncommon for a component or subsystem to be designed into equipment in the breadboard or prototype phase only to discover at a later time that item does not conform to the conditions of the procurement specification. Naturally, costs start increasing if redesign or requests for waiver are necessary.

One prime contractor supplying a communication system was required to meet the mil spec temperature range of −55°C to +125°C. Designers of associated digital equipment knew that their equipment would be housed in a controlled (air conditioned) environment, thus they designed around a memory system that would operate only from 0°C to 75°C.

While no functional problem was posed, under ideal conditions, the system would not technically meet the contract requirements. The contractor had a choice of redesigning or requesting a waiver. Fortunately, the waiver was granted, but this is not always the case. It is best to become thoroughly familiar with the contract provisions, so they may be used in specifying all the system components.

Vendors Are Responsible Too. Purchasing a part or a subsystem to a contract can be a problem, especially if it is difficult to find the required parts in the QPL, internal standard, or approved parts lists. Remember, the contract applies to the subcontractors and vendors too. However, the burden of fulfillment is the contractor's responsibility at delivery. Usually, an incomplete specification sent to a vendor or subcontractor becomes the major culprit. It is extremely important that all components and subsystems be specified in detail. As a guide, a mil spec includes:

- Brief description (scope)
- Important operating parameters
- Reliability and integrity of the component
- Mechanical and physical description
- Environmental requirements
- Special documentation, such as reliability verification and analysis
- Quality Assurance Procedures.

There are several methods to avoid trouble when working with military and federal specifications and standards. First, become intimately familiar with the provisions of a RFQ or procurement specification before becoming involved in quoting or design. Secondly, have access to an efficient, complete, and up-to-date file on the major specifications and standards needed for a given project. Finally, when in doubt, seek clarification from the originator of the request-for-bid or procurement specification. Both the U.S. government and private industry can provide military and federal specs and standards, plus many of the related documents that are needed in most government contract work.

Government Sources. Government documents are available in hard-copy or microform, depending on the source of supply. In either case, indexes are essential for rapid retrieval of needed documents. The U.S. government offers two indexes to specs and standards: *the Index of Federal Specifications, Standards and Handbooks;* and the *Department of Defense Index of Specifications and Standards (DoDISS).* The General Service Administration issues the Federal index, which lists all Federal specifications, alpabetically and numerically. The information includes Federal standards, common- use military specifications, Federal Qualified Product Lists, and related information. Each month a cumulative supplement is issued. This index is puchased on a subscription basis from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Three sections make up the DoDISS - Part I, an alphanumeric listing; Part II, a numerical listing; and Part III, a NSC listing. Part II identifies federal specifications, military specifications, federal standards, military standards, QPLs, and cancelled documents by number. Cumulative supplements are issued annually and the publication is also purchased from the Superintendent of Documents. However, reference copies are available at most military installations, procurement offices, and Small Business Administration regional offices.

Generally, copies of the listed specs in an invitation to bid are available without charge at the responsible government purchasing office. Government Depository Libraries have copies, but the completeness of the file depends on how long they have been receiving the publications. Prospective bidders can obtain copies of the standardization documents free of charge by request to the Naval Supply Depot, Philadelphia, PA. The request must identify the document with the symbol and title as listed in DoDISS. All amendments and revisions are automatically issued with the basic specification.

Based on Federal Supply Classifications, new and revised documents listed in DoDISS are available to industry on a subscription basis. The list of "Federal Supply Groups and Classes" in the Handbook H2-1 establishes these classifications. Automatic receipt of any revisions or amendments of a given specification is ensured by the subscription service. Thus, eliminating the necessity of ordering or locating all applicable specifications and standards each time a solicitation is received. Requests for drawings, sketches, instructions, and other similar documents appearing under the "Specification" heading are obtained from the contracting office.

Most military installations have a small business advisor that provides information on the proper procedures, and assists in obtaining copies of all available specifications. A subcontractor obtains the necessary data from the prime contractor prior to accepting the subcontract to assure complete understanding between parties. The major problems associated with hard-copy documents include delays in obtaining documents, difficulty in keeping files current, lack of

historical information, and space requirements.

In view of the number of specs and standards required in any sizable project, it's not surprising that occasionally a document will be out of print. This could result in a delay of a few days to a few months.

Keeping the files current is not only time-consuming, but also subject to error and to delays associated with distribution and filing. Once a document has been superseded, it will no longer be printed. Therefore, historical information, which may be important for delayed contracts and revisions or additions to existing equipment, may be difficult to obtain or completely unavailable when needed. The sheer bulk of extensive hard-copy files is not only a space and cost problem, but may also make retrieval more time-consuming and inconvenient.

What Are Specifications and Standards?

Military and Federal specifications and standards, Military Handbooks and Qualified Products Lists (QPL) are important elements to aid the Department of Defense (DoD) in the efficient procurement of equipment and services for military needs. Understanding the purpose and function of each will help contractors to work more efficiently within the federal government procurement system. Also, they will help the inexperienced avoid many pitfalls.

Military Specifications issued by DoD, define materials, products or services used only or predominately by military activities. Two basic types are "coordinated" and "limited coordination." Coordinated are circulated to an extensive list of military departments for sign-off approval and are considered of general interest to all DoD operations. Limited coordination specification is of interest to a limited group only and goes through a less involved approval cycle.

To illustrate the titling format, consider the military specification for an attenuator.

MIL-A-18199 (AER)
15 September 1954

Supersedes
16A47 (AER)
Dated 15 March 1948

The prefix MIL identifies this document as a military spec. A code letter (A) represents the first letter of the title for the item. In this case, the item is an attenuator. The last group of numbers (18199) is the assigned serial number, followed with the latest revision letter (I, O, Q, and S are not used). In this example, there have been no revisions. The last set of letters (AER) identifies this as a limited coordination spec. AER is the activity's symbol (Air Force). If the specification is later converted to a coordinated specification, the (AER) symbol will be deleted. The date immediately under the title shows when it was released and the document this spec replaces is listed under the release date.

Military Standards provide the procedures for design, drawing, writing and testing rather than giving a particular specification. The following example illustrates how the military standard for testing electron tubes is titled.

MIL-STD-1311B
28 March 1975

MIL-STD-1311A
Superseding
25 March 1970

Prefix MIL identifies this as a military document. However, the following letters, STD, never change and label this as a standard document. The last group of numbers (1311) is the assigned serial number followed with the latest revision letter (B). The release date is under the title (28 March 1975) and this document supersedes the revision listed under the date (Revision A).

Military Standardization Handbooks are detailed handbooks describing a specific subject that is critical to military design. The title is comprised of the prefix letters MIL-HDBK followed by an assigned serial number. For example, MIL-HDBK-241 is the Design Guide for EMI Reduction in Power Supplies.

Federal Specifications. The General Services Administration (GSA) is the cognizant agency for federal specifications. These are similar to mil specs except they are written primarily for federal agencies. However, Federal specifications are acceptable in a DoD environment when a mil spec does not adequately cover the subject.

Each specification is reviewed for revision every five years. There are exceptions. For example, some specifications may require immediate consideration because technological advancements have made them obsolete.

The following example (general specification for aluminum alloy) illustrates the titling format used to identify Federal Specifications.

QQ-A-200D
20 August 1970

Superseding
QQ-A-200C
5 June 1965

The Federal specification is recognized by the first group of letters (a maximum three) (QQ). The single letter prefix (A) is the first letter of the item's name that the specification describes. In this example, the subject is aluminum. The following set of numbers is the assigned serial number (200), followed by the latest revision letter (D). The release date of revision D was 20 August 1970.

Federal Standards provide guidelines for design and testing rather than specifying an item. An example (methods for testing adhesives) of the document title is:

FED-STD-175A
25 November 1975

Supersedes
FED-STD-175
27 September 1967

The standard is recognized by the lettering prefix FED-STD. The block of numbers (175) is the assigned serial number with revision letter following (A). Released date of revision (A) was 25 November 1975.

Qualified Products List (QPL) is a cataloging of products such as fuels, metals, tools, and some electrical equipment (i.e., fans and motors that meet government specifications). The QPL, either Federal or Military, is prepared for only those specifications that require prequalification tests. When a specification is released, all manufacturers can submit any general type product covered by the specification for qualification tests. However, the manufacturer pays for the testing.

Inclusion on this list does not exempt the item from further acceptance inspections, or mandatory source inspections. In any case, the end user is responsible for the ultimate reliability of the item.

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Reliability: The Quest for Semiconductor Perfection

by
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During daily production of semiconductor devices, tests must be conducted to consistently ensure the buyer that he is receiving a reliable device. In satellite circuits, military systems, or other applications, device reliability is crucial. The techniques and problems discussed here emphasize the inherent difficulties involved when testing semiconductor devices. Failure often stems from constraints of size, current density, junction temperature, electric field concentrations, and pulse sensitivity.

Reliability can be improved if weak or failure-prone devices can be removed by a sequence of appropriate stresses and tests. By subjecting devices to a series of thermal and mechanical conditions known to activate failure modes, weak devices will be eliminated. This will leave only those with long term reliability. The total success of such screening and preconditioning depends on the chosen stresses, the combination of stress conditions, and the length of time that the conditions are applied. Conditions must fit the device being tested, and they must be consistent with the operational environment. When running these tests, it is important that the devices be stressed to their maximum ratings. In some instances screening may be performed under conditions in excess of the maximum ratings. Of course, it must be previously established that these conditions neither weaken nor cause failures in good devices.

The small size of microwave semiconductor components makes moisture control of nonhermetic packages a difficult quality-assurance problem. Since only 10 to 15 mils of seal width are typically used, the task of achieving a good hermetic seal is challenging. Standard IC packages require 20 mils or more to achieve a good seal. Size limitations dictate that bonding pads and wires be much smaller than is mechanically optimum. Small packages also pose problems with wire-to-chip clearance and bond placement. Hence, operator techniques require considerable precision and care. Many of the problems related to bonding are avoided by using beam lead devices instead of conventional chips. Fig. 1 shows the relative occurrence of some failure mechanisms.

The operation of step recovery diodes and IMPATT diodes often results in high current density, and junction temperatures of 200°C to 250°C. This combination places extreme demands on the diode metalization systems. Metal cleanliness, thickness, and uniformity all must be controlled to give the required stability of the metal and its interface with the semiconductor material. The high voltage of IMPATT diodes also produces high electric fields. This can result in catastrophic breakdowns if separation of anode and cathode metalization is reduced, or if surface irregularities locally increase the field intensity, as in Fig. 2.

Field effect transistors (FETs) are operated at lower voltages than IMPATT diodes, but they still produce electric fields between the gate and source, approaching material limits. Local variations of the submicron gap between gate and source can result in a sudden and permanent cessation of operation due to arc over. The gate of FETs and the junction of low voltage Schottky diodes are especially susceptible to damage from transients of static electricity pulses. Transient suppressing networks used on CMOS and TTL circuits cannot be used on microwave diodes since the added capacitance would reduce microwave performance.

Detection of faults early in the manufacturing process can lead to prevention of costly failures. Since the margin for error is small and many processing steps are involved, the reliability of individual devices in a lot can differ substantially. Thus, it is valuable to activate failure mechanisms in finished devices for two reasons. First, to remove devices which may fail later. Secondly, to evaluate the composition of a given lot.

Visual examination before the final sealing step is a valuable form of reliability screening, providing a last check on physical conditions of the chip, bonding, wire placement, and die attachments. The presence of particles which could cause shorting can be better detected before seal than in any post-seal x-ray. Scratches or nicks in the die active area made during assembly must be detected. Inspection identifies many reliability hazards when performed on all of the devices, so no compehensive evaluation should exclude it. But final seal is a process step which can introduce its own reliability hazards. Conductive particles from the solder or weld can splatter and damage the chip. Or worse, splatter may land where it can become a loose particle within the package, thus shorting the device at some later time (Fig. 3).

A more common defect occurs when the sealing process does not completely seal the package. A hermeticity test must be able to detect any leakage path whether large or small. Most hermeticity tests of MIL-STD-750B do not work well for small microwave packages. Although helium leak tests can be used, extreme care must be taken to avoid false results due to the effect of the small cavity size. Components are subjected to a high-pressure helium process (called bombing), after which the surfaces are cleansed of helium. The enclosed helium may dissipate too quickly to be detected. Time between bombing and detection is critical, and it must be short to provide an effective test. Under standard operating conditions, the range of detectable fine-leaks does not overlap the range of detectable gross-leaks. The radioactive gas test is effective over a wider range of leak rates. This test is less sensitive to package volume, hence it is a preferred time-leak test method for microwave devices.

The most commonly used gross-leak test method is the bubble test. Despite its popularity, this method is inadequate for microwave packages. The internal volume may be so small that one bubble is all that can be expected. Absence of a bubble stream is not enough proof that the package is well sealed. Even the best operators reject some hermetic devices, and accept some unsealed devices. A method that has proved satisfactory, however, is a modification of Method 1071 Condition A, the wet radioactive gas gross-leak test. Pressure is used to force oil into nonhermetic devices. The radioactive gas entrapped in the oil is detected by the scintillation counter and the gross-leak is then apparent (Fig. 4).

MIL-STD specified environmental and mechanical stresses are applicable to microwave semiconductors. The sequence of the tests should always be thermal stress followed by mechanical stress. The levels of useful mechanical stress which can be applied to a device, typically result in relatively small forces. However, the screening effectiveness of such mechanical tests are substantially improved by thermal preconditioning. Poor bonds may be sufficiently weakened by thermal stress so that the relatively low mechanical stress can complete the failure. The electrical result of bond or contact whisker movement is readily detectable by changes in I, or V_1, measurements. To detect V_1 changes, current should be large enough to ensure detection of small increases in resistance.

While temperature cycling, temperature storage, and mechanical stress are valuable for lot evaluation and 100 percent screening, care must be taken to include discriminating failure criteria. Low power devices with single bond wires will fail electrical tests if a bond opens. Many devices have two or more parallel bond wires to reduce inductance. In these cases an output power test may be required to detect an open bond. Step recovery diodes, IMPATT diodes, and some PIN diodes are included in those which may have parallel bonds. Since a simple V_1 test may not be sufficient to detect an open bond, it is important to use the right evaluation test criteria after a given stress sequence.

Similarly, temperature cycle and thermal shock stress should be followed by hermeticity tests as well as electrical tests. Although it is expensive, electrical tests may be required during vibration tests to detect intermittent open circuit or short circuit conditions.

High Temperature Expedites Testing. High temperature reverse bias (HTRB) stress is essential in the evaluation and screening of some devices. Evaluations of step recovery diodes should include HTRB, since their application includes reverse bias. An increase in leakage can detrimentally affect devices and thus circuit performance. PIN diodes should also be evaluated by HTRB unless their application is limited to forward or low voltage reverse bias. For applications that do not involve reverse bias, there is typically no correlation between reliability and HTRB performance. Device characteristics important to the forward bias operation do not change as a result of HTRB testing. Many available PIN diodes have a nitride passivation which practically eliminates HTRB degradation due to ionic drift or surface change. If HTRB stress is to be included in an evaluation or screening program, the highest temperature compatible with the package should be used for maximum effectiveness since the rate of failure has been shown to have an exponential (Arrhenius) relationship with temperature. HTRB is an economical, high temperature, short duration stress; and its use can give high assurance that a lot is stable.

Operating life is always a useful screening and evaluation tool. The best stress conditions depend on the mechanisms that are most likely to cause failure in the application. Commonly used conditions are either dc forward bias, or 60 Hz forward and reverse bias at either 25°C or an elevated ambient temperature. High frequency operation is generally not required. The conditions of current density, voltage, and temperature should approximate device maximum ratings as closely as possible.

Failure mechanisms such as degradation of the contact and/or metalization are activated by high current density and temperature. Operating power may have to be less than maximum if adequate heat sinking is not possible through the test sockets. Power should be sufficiently high to cause a device with high thermal resistance due to a packaging fault to run hot and thus fail. On the other hand, power must not be so high that variations in test socket heat sinking will cause sound devices to fail by overheating.

DC operation places the most stress on the contact metal. AC tests are less effective in this respect, but add a temperature cycling effect

that mechanically exercises the material interfaces and bonds. By using intermittent operating life (five minutes on and five minutes off), the temperature cycle effect can be increased. The most applicable condition depends on the failure mechanisms of the device type and the application.

For example, dc operation is advantageous for IMPATT and step recovery diodes, while high current operation makes the migration of metal into the semiconductor material an important failure mechanism. DC test conditions are also prefered for low power Schottky devices, since the reverse bias portion of an ac test increases the chance of damage to the junction by transient voltage (Fig. 5).

Should Microwave Test Frequencies Be Used? When testing the operational lifetime of microwave devices, it is popular for tests to be performed at microwave frequencies. This is because the device is thought to be most efficiently tested if it is stressed at its maximum thermal conditions while being subjected to the idiosyncracies of microwave operation. However, the instrumentaion complications at microwave frequencies make this impractical. Microwave test equipment, such as signal generators, are very costly if one is to obtain the kind of power necessary to operate a significant number of devices simultaneously. Also, all of the microwave circuit considerations such as matching and losses become compounded when trying to run a large quantity of devices under microwave conditions. In addition to the complications of implementing such a life test, the problems of mounting devices in microwave circuits without damage often represent a significant difficulty.

It has been established through many years of experience that the best indications of microwave device life expectancy are achieved using dc or very low frequency ac operating conditions. Maximum temperatures at which the defect modes are usualy activated can be economically and simply achieved, and better controlled. It has also been demonstrated that changes in dc parameters are more easily detected, and that they occur prior to the point at which degradation of microwave performance would result. Hence, the dc stress conditions and the dc measurements are better indicators of life expectancy in the microwave operating conditions than would be the microwave stress condition.

Most failure mechanisms associated with degradation of semiconductor junctions, increase of contact resistance, and changes in the surface potential can be caused more quickly by elevating the temperature (Fig. 6). The failure rate at a given temperature is related to failure rates at other temperatures by an exponential function, which includes a constant times the reciprocal of temperature as an exponent. The constant is defined as the activation energy. Higher activation energy indicates a higher dependence of failure rate on temperature. Within certain bounds, temperature can be used to compress time during screening tests. For example, one hour at 200°C has the equivalent aging effect for some mechanisms as 100 hours at 125°C. In order to use this phenomenon effectively, device failure mechanisms must be understood. If properly applied, the efficiency of high temperature life testing can be multiplied dramatically over that of 25°C operational testing.

Failure Criteria Must Be Clearly Defined. The definition of a failure is very important in determining whether the screening and preconditioning tests have caused the device to change excessively. The failure definition tailored to the particular characteristics of each device, and the relationship between dc drift and RF performance need to be studied in order to determine discriminating dc drift limits. In such studies it is often found that the dc drifts precede changes in microwave performance. Thus, they can be used as sensitive indicators of the approach of greatly reduced performance or device failure.

Screening tests which do not produce failures mean either that the device is exceptionally reliable, or that the failure specified limits are too wide to identify excessive drifts. Assuming the conditions and the limits specified for screening tests are both sensitive and discriminating enough to be good reliability limits, then a reasonable number of failures indicate that the screening is, in fact, doing its job. A high percentage of defective devices might indicate that continued evaluations would screen additional failures from the lot. It would follow that the infant mortality failures have not been sufficiently screened, and the lot may not have the level of reliability expected. Hence, a high percent defective is reason to be suspicious of the lot. Ten percent of defects is a typical number to specify in order to consider the lot acceptable after screening.

Because of their frequency response, microwave diodes and transistors are much more susceptible to the possibility of oscillation during operational lifetime tests. Typically, printed circuit boards are used to test a quantity of devices simultaneously. The high gain of the device, the particular circuit capacitances, and circuit board feedback paths can often result in uncontrolled oscillation. This oscillation results in uncontrolled dissipation levels which make the reliability results useless. Precautions have to be taken to introduce losses, thus reducing the probability of oscillation. During the operational lifetime tests, regular checks must be made to assure that oscillations have not occurred.

Microwave devices, because of their close spacings and shallow junctions, are especially vulnerable to degradation due to transient or static electricity discharges. Protection from such exposure is required throughout packaging for shipment, handling, preparation of introduction to the circuit, and testing. Test equipment has to be free of pulses caused by switching or other sources. Fixturing has to be positive in contact so that erratic contacts caused by bounce or weak springs are not present. A representative screening program is shown in Table I.

TABLE I
REPRESENTATIVE SCREENING PROGRAM FOR A MICROWAVE TRANSISTOR

Test	Objective
Water Fabrication	
SEM Inspection	Workmanship defects
Bond Strength	Assure metal adhesion and bond quality
Die Shear	Assure metal adhesion and bond quality
Assembly	
Precap	Workmanship defects
Electrical Test	Electrical sort and reference data
Temperature Storage	Activate mechanisms that cause drift
Temperature Cycling	Stress material interfaces
Constant Acceleration	Stress material interfaces
Leak Tests	Screen for hermeticity
Hi Temperature Reverse Bias	Activate drift mechanisms caused by contamination
Electrical Test and Deltas	Detect excessive drift and establish degree of stability
Operating Life	Activate mechanisms caused by current and junction temperatures
X-Ray	Detect final configuration defects and particles

Different Tests for Different Folks. Reliability assurance for chips or beam lead devices is an entirely different matter. Reliability activities are the same for these devices through all of the steps of wafer fabrication, but following this point their handling is different from those devices which become packaged. Many of the stress tests cannot be made because there is difficulty in making suitable contact which will not damage the unpackaged device. Screening of 100 percent of a lot is limited to nonoperating stresses, such as temperature cycling and temperature storage. Other evaluations of the lot can be accomplished on a sample of the appropriately packaged chips.

A representative reliability program for dice would be something like the following. The lot of dice would be subjected to a temperature storage test at its maximum rated conditions for a week. It may then be subjected to temperature cycling tests from low to high temperature extremes consistent with its maximum ratings. The devices would probably then be 100 percent visually inspected for individual defects. A dc electrical probe test would check the electrical characteristics after the screening tests. Several devices would be mounted into a standard package. At that time, the die-attach and bonding characteristics would be checked. The hermetically sealed sample would be subjected to a reliability evaluation program. If the results are satisfactory, the device would be released for shipment. Because the reliability evaluation of chips and beam leads is not 100 percent effective, failure rates cannot be assured. Further screening during the final application is the responsibility of the device user. It is recommended that after devices have been mounted in their intended circuit, the assembly should be subjected to appropriate stresses. This conditioning and testing not only checks the reliability of the devices, but also checks the handling and assembly techniques. The metalized fingers of Fig. 7 exemplify the type of close clearances which must be checked for flaws.

Semiconductor manufacturers test devices at a number of reliability levels. These include tests imposed by individual customers, and others designed by the manufacturer for meeting the needs of many customers. The customer specifies screening and reliability confirmation tests which he feels are necessary for his particular application. Some apply their own standard program to devices to provide a consistent level of reliability for all components. The severity, and consequently the cost of such programs depend upon the program details.

The Department of Defense specifications for military devices use the JAN prefix to denote the level of reliability. These include the JAN device (e.g., JAN1N5711), which receives a lot acceptance Group B type program (group B testing is sampling evaluation) and the JANTX device (e.g., JANTX1N5711), which receives preliminary screening followed by a Group B test. Also included is the JANTXV device (e.g., JANTXV1N5711), which gets a screening program with visual inspection followed by a Group B test. These programs deliver three succeedingly higher reliability levels, which are based on the MIL standard reliabililty tests used universally. These MIL programs are sometimes used as starting points by customers who want to specify their own programs.

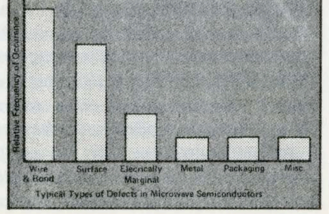
Another available option is a reliability program prepared by the semiconductor manufacturer, who is in an excellent position to judge the effectiveness of a given test and its contribution to the reliability of his product. They are run routinely by the manufacturer in much the same way that military JAN type programs are run. At Hewlett-Packard many of these devices are catalog items and can be purchased off-the-shelf. The higher volumes that can be run represent cost savings to the customer. Usually the reliability is equivalent to military devices and, therefore, a cost effective option.

After all tests are completed, a chance remains that a reliability hazard was undetected. It is worthwhile to sacrifice one or more devices for a closer look. After the package is carefully opened, a visual examination can determine whether the interior is still as clean as it was prior to sealing. Bond strength can be determined by bond-pull tests. If aging has had an effect, the results may differ from previous in-process bond-pull results. Photographs can document the exact configuration of the chip and its assembly. The superb depth of field with high magnification makes the scanning electron microscope an especially useful tool for destructive physical analysis.

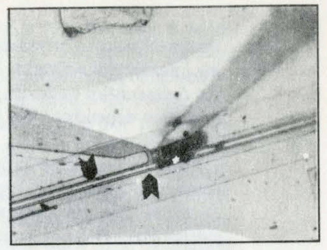
Organizations other than the manufacturer can administer screening. Reliability testing companies are usually well equipped for the types of devices they screen. Often they can complete a program in less time and at lower cost than the manufacturer. Since they have no direct responsibility for the reliability of the manufacturer's device, they are viewed as having an unbiased attitude. For large volumes and commonly used devices, reliability testing companies are quite cost effective. However, the outside reliability test house often has difficulty with highly specialized, lower volume products, since special tooling may be required. Special handling may not be compatible with their standard procedures for high volume products. Hence, microwave devices do not readily lend themselves to outside screening. Usually manufacturers maintain in-house test equipment.

While the outside test house can screen according to a prescribed specification, the customer is at a disadvantage if problems requiring corrective action by the manufacturer develop. The manufacturer will have to be convinced that the tests were appropriate and applied correctly, since the manufacturer is ultimately responsible for the finished product.

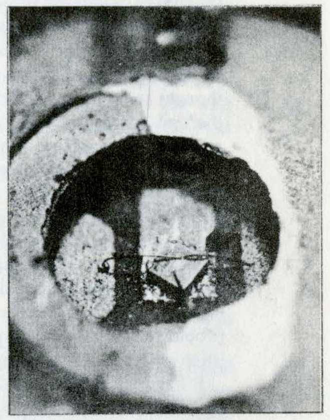
Reprinted from MSN, November 1977



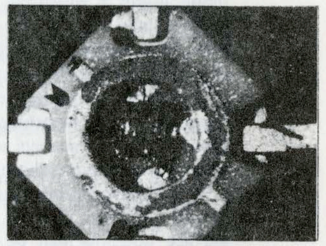
1. A typical distribution of the causes of failure in packaged microwave semiconductors. The actual distribution will vary by device type, manufacturing lot, and environmental conditions.



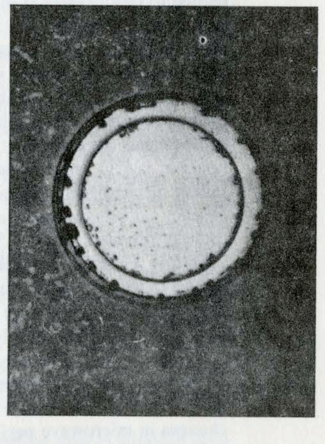
2. A small protrusion similar to those shown at arrows probably caused an arc between gate and source of this GaAs FET. Devices with no irregularities must still be protected from abnormal transient voltage spikes. The standard precautions for MOS ICs are applicable and adequate.



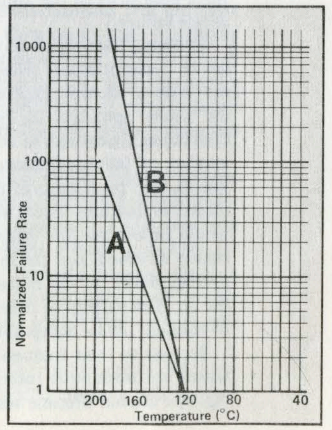
3. A minute particle between the emitter bonding wire and the chip edge has caused a collector-to-emitter short. The fault was activated by subjecting the device to thermal and mechanical stress to loosen the particle, which may have been weakly attached to the wall of the package. The electrical short was detected during a vibration test with bias.



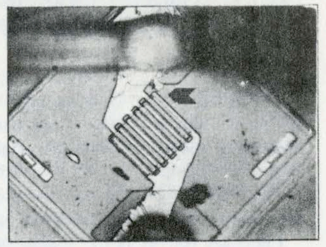
4. Area between the arrows was not wetted by the cap solder. The MIL standard bubble test cannot detect many gross hermeticity rejects of this magnitude. A wet radioactive gas gross-leak test detects this kind of hermeticity leak with nearly 100 percent confidence.



5. The contact button and barrier metal of this Schottky diode have been etched away. The dark spots at the periphery were caused by repeated short electrical pulses. The device developed a soft reverse bias characteristic but maintained normal forward bias characteristics.



6. Acceleration range of most temperature dependent failure mechanisms. The lower boundary (A) refers to movement of ionic charge in the oxide passivation. The upper boundary (B) applies to penetration of metals into the silicon. Some failure mechanisms are not temperature dependent and a few are reported to have a higher slope than that shown by slope B.



7. There is extra metal between the bonding pad and the end of the base finger of this bipolar transistor. This is an example of the difficulty in inspecting separation between metalized fingers of micron geometries common in microwave components. The SEM or high quality optics are required for adequate inspection.

Defining Quality Limits and Lot Tolerance

For each scientific sampling plan, such as those in MIL-STD-105, a curve can be computed to show the sampling plan's ability to differentiate between accepting and rejecting lots where percentage of defective products may vary over a range of percent defective. The curve is the operating characteristic of the sampling plan. The OC curve is a plot of the probability that the sampling will give an accept-decision for production lots where the percent defective is within the range of the curve. An example of the curve for a sampling plan follows with the AQL and LTPD points shown in the accompanying graph. AQL stands for "acceptable quality limit," while LTPD is "lot tolerance percent defective." These represent the quality levels which are found at either end of the sampling plan curve.

AQL is the value of percent defective which intersects the curve at the 95 percent accepted point. (The 95 percent is not firmly fixed and varies from that value for many sampling plans. It's a generally used value in describing AQL, however.) It means that percent defectives at or below the AQL value will be accepted by sampling almost all of the time. Quality worse than the AQL will have a poorer chance of being accepted. It is used as a value which indicates the quality levels a manufacturer must maintain in order to have most of his lots go through a quality assurance sampling inspection. If quality gets worse than the AQL, the manufacturer will get more lots returned for retesting.

The LTPD point is the percent defective which has only a 10 percent chance of being accepted. Plans designed as LTPD sampling plans are intended to fix at 10 percent a top limit for poor quality. In the example, lots with greater than 5 percent defective devices would be accepted less than 10 percent of the time and rejected over 90 percent of the time. When reliability is the objective, a poor lot cannot be tolerated. Since an LTPD plan minimizes the possibility of a very poor lot being accepted, it is frequency used for reliability work.

Reprinted from MSN, November 1977

Interesting Items

Women in the Sciences

A study of the professional status of male and female members of the Academy of Management found that women members appeared to perceive and experience a less favorable professional environment than men. Male respondents perceive a significantly more positive university enrollment for women members of the Academy than do the female respondents. Male respondents reported a significantly higher monthly income than females, although there was basically no difference in their reported ages. For women, the average salary falls within the lower end of the $1401 to $1600 range while men fall within the upper end of the $1601 to $1800 range.

NSF Rotator Program Seeks Minorities and Women

The National Science Foundation seeks to increase representation of minorities, women, and handicapped persons in its rotator program. This program is designed to augment the permanent staff of scientists and other professional employees at NSF with faculty members of colleges and universities who will serve in non-career positions for terms of one to two years. Scientists with a Ph.D plus six years of scientific research are particularly welcome. The application deadline is September 1, 1977. Interested persons should send vita and statements of interest to Herbert Harrington, Jr., Director, Office of Equal Employment Opportunity, National Science Foundation, Room 536, 1800 G Street, N.W., Washington, D.C. 20550.

Women Do Better In Washington

Women in Washington, D.C. are more likely to be working, and working full-time than are women in other parts of the country, but the male/female earnings gap is wider there than elsewhere. In the Washington, D.C. area, the average salary for a woman white collar worker is $12,742, compared with a male average of $22,202. Women scientists face the same problems as other women in their efforts to move upward, and, unlike either men or members of minority groups, the higher the credentials for women, the wider the gap between them and similarly qualified men.

New IEEE Newsletter, "Women Engineering Students"

The purpose of this newletter is to serve the special interests of women engineering students on college campuses in the United States. Articles for and about women engineers, both students and professionals, are featured.

In its second year of publication is *The Women Engineering Students' Newsletter*, sponsored by IEEE's Committee on Professional Opportunities for Women (COMPOW). The most recent issue contains news of the professional organization WISE (Women in Science and Engineering), of college groups formed to promote the interests of technical-minded women, and of courses, workshops, conferences, and books for and about women engineers and engineering students. Also in this Spring issue are accounts of the personal experiences of two women, one a graduate student in nuclear engineering at Purdue, the other a co-op engineering student at Detroit Diesel Allison Division of General Motors. Violet P. Hass is the editor.

NSF Women in Science Program

The National Science Foundation (NSF) has made 34 awards totaling $907,640 for projects designed to increase participation by women in scientific careers. Women presently constitute 51 percent of the population, but only 6 percent of those employed as scientists and engineers.

The awards, made through the NSF's Women in Science Program, are for two types of projects aimed at developing and testing methods for attracting and retaining women in scientific careers. Included is $229,330 for 24 Science Career Workshops in 18 States and the District of Columbia and $678,310 for 10 Science Career Facilitation Projects in 7 States.

Women Ph.D. Scientists/Engineers Not Faring As Well As Men

Women Ph.D.'s in science and engineering continue to make less money and find themselves out of work more often than their male counterparts. These are the central findings of two recent National Research Council reports.

According to the 1975 profile, the median annual salary for all men and women doctoral scientists and engineers was $23,000, with engineers earning the highest median salary - $25,000. The median salary for men was $23,500, while the median for women was only $19,000. Female doctoral engineers fared slightly better: their median salary was about $21,000 compared to over $25,000 for male engineers.

The 1975 profile also indicates the unemployment rate among female science and engineering Ph.D.'s is significantly higher than it is for men: 3.0 percent for women, 0.8 percent for men. The percentage of women who were employed part-time and seeking full-time employment in 1975 was 2.4 percent compared to 0.5 percent for men; in 1973 the percentage of women was 3.5 percent and 0.7 percent for men.

Women Academic Scientists and Engineers Increase in 1976

The number of women employed full time as scientists and engineers by universities and colleges reached 35,900 in January 1976. This was the second consecutive year that their numbers have increased by 5 percent. Men, still far outnumbering women, totaled 194,600 in 1976, but their rate of increase was only 2 percent in each of the last two years.

These data resulted from NSF's 1976 Survey of Scientific and Engineering Personnel Employed at Universities and Colleges.

Despite the higher growth rate of women, there has been little change in their share of the full-time scientists and engineering total - up from 15 percent to 16 percent between 1974 and 1976.

Aerospace Employment Levels Off

U.S. aerospace industry employment will stabilize at approximately 895,000 workers by June 1977, according to a survey by the Aerospace Industries Association.

This projected leveling off in employment would end a major decline which started in 1969 from a 1968 peak of 1,500,000 workers.

The aircraft manufacturing segment is showing signs of renewed vitality, and by June 1977 will employ 477,000, an increase of 1.3 percent from December 1976. This new vitality is based upon new orders for transport aircraft from domestic airlines, domestic and international demands for new and replacement military aircraft, and the continuing strength of the general aviation sector of the industry.

The survey estimates that employment on missile and space programs will continue to decline throughout the period covered by the survey, with an 11 percent drop from December 1975 levels. The category of "other related products" - avionics, non-aerospace and basic research - continues its overall upward trend to 245,000 by June 1977.

Beware of Indoor Air Pollution

In a report prepared for the Energy Research and Development Administration, scientists at Lawrence Berkeley Laboratory warn that air pollution "indoors" is frequently worse than pollution levels outdoors. Typical indoor air pollutants include: carbon monoxide, nitric oxide and nitrogen dioxide from gas stoves and furnaces; carbon monoxide and other substances in cigarette smoke; vinyl chloride and fluorocarbons from aerosol spray cans; and organic compounds from products used in cleaning, cooking, etc. "The importance of indoor air pollution, only now being recognized, will ultimately have a large impact on the design of energy conservation strategies for buildings and on the need for more stringent control of air pollution from indoor sources," the report states.

IEEE Publishes Guide

A new standard on electrical noise in controllers has been published by the Institute of Electrical and Electronics Engineers, Inc. "Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources," IEEE Std 518-1977, is a basic handbook on the installation of industrial controls involving low-energy level equipment to assure minimal noise inputs from external sources. Copies of the guide are available from IEEE Service Center, 445 Hoes Lane, Piscataway, New Jersey 08854. Price is $10; IEEE members, $9. An additional $2 handling/shipping charge must accompany each order.

Wage Incentives Study Released

A recently completed survey shows there is no significant trend toward disenchantment with wage incentives. The study, directed by the American Institute of Industrial Engineers and Patton Consultants, Inc., reveals that 89 percent of those who participated are using work measurement and 44 percent are using wage incentives. Companies which have wage incentives reported an increase in coverage along with favorable attitudes toward incentives. "When work measurement can result in a 25 percent increase in productivity and further application of wage incentives can give a 50 percent increase in productivity, it is inconceivable that 60 percent of all U.S. manufacturers have not taken advantage of these measures," according to John A. Patton, President of Patton Consultants, Inc.

IEEE Seeking Delegates To Attend 1978 USSR POPOV Society Congress

The IEEE is seeking delegates to attend the 1978 USSR POPOV Society Congress as part of its annual exchange. Members are requested to submit applications, together with a biography, to their respective Group or Society presidents as soon as possible.

The POPOV Society has advised that its four-day Congress will take place in Moscow in the latter part of May 1978.

Plans are for the IEEE delegation to stay in the USSR about two weeks, attending the Congress and visiting several Soviet cities, where they will tour research centers, educational institutions, and operating installations.

Applicants will be expected to provide their own funding for the trip. As a rule, the delegates have been funded by their own institutions or companies. However, in past years a limited number of delegates from academic institutions have been funded by the National Science Foundation, but this number has been small and it would be to your advantage to try to obtain your own funding.

The exchange will focus on the technical interests around Division III, i.e., Aerospace and Electronic Systems; Broadcast, Cable and Consumer Electronics; Communications; Electromagnetic Compatibility; Geoscience Electronics; and Oceanic Engineering. Members of other Groups/Societies in related fields may also apply.

Nominees will be recommended to the TAB Transnational Relations Committee (TRC) from applications made to the respective Group and Society presidents. The TRC will recommend to TAB OpCom those nominees whose interests best coincide with the sites and topics suggested by the POPOV Society. In making nominations, it is expected that the Group and Society presidents will give precedence to applicants who are likely to be known by their Soviet hosts through professional achievement and/or positions.

Further information may be obtained from Dr. Jerry Sevick, Chairman, TRC, Bell Laboratories (Rm. 3D-590), 600 Mountain Avenue, Murray Hill, New Jersey 07974 - Telephone: (201) 582-3717.

NSPE Selects Engineers Week Theme for '78

"Engineers...Strength in Crisis" will be the theme for 1978's National Engineers Week, scheduled for February 19 to 25, according to the National Society of Professional Engineers (NSPE).

Commenting on the theme, Vincent S. Haneman, Jr., dean of engineering at Auburn University and head of the Engineers Week Committee, notes, "America is faced with crises from every quarter - vanishing mineral resources, energy shortages, environmental deterioration, water supply shortages. At times, it appears our entire existence is threatened. But the American genius is our ability to solve problems. No figure embodies this attribute more than the engineer. During Engineers Week, we celebrate the leadership with which engineers continue to provide the nation.

"No matter what the crisis," Haneman continues, "ingenuity is our strength. At a time when it appears America's resource base is eroding, it's refreshing to realize that one of our most valuable resources - engineering - is renewable."

NSPE has sponsored National Engineers Week since 1951, providing its state societies and local chapters and other groups of engineers with a variety of information and promotional material to aid in drawing public recognition for local activities focusing on the week's theme.

Writing As It Should Be Writ or Rules Of The Game

1. Each pronoun agrees with their antecedent.
2. Just between you and I, case is important.
3. Verbs has to agree with their subjects.
4. Watch out for irregular verbs which has crope into our language.
5. Don't use no double negatives.
6. A writer mustn't shift your point of view.
7. When dangling, don't use participles.
8. Join classes good, like a conjuction should.
9. Don't write a run-on sentence you got to punctuate it.
10. About sentence fragements.
11. In letters themes report articles and stuff like that we use commas to keep a string of items apart.
12. Don't use commas, which aren't necessary.
13. Its important to use apostrophe's right.
14. Don't abbrev.
15. Check to see if you any words out.
16. In my opinion I think that an author when he is writing shouldn't get into the habit of making use of too many unnecessary words that he does not really need.
17. Last but not least, lay off cliches.

(Reprinted from Capital Letter for September, 1976, Washington,D.C. Chapter, Society for Technical Communication)

Are You the Missing Member?

Are you the missing member
The kind who would have liked
To get involved and mingle
If you didn't have to fight
Through forty miles of traffic
In rush-hour Grand Prix style
To meet at some far outpost
That lasts for quite a while?
After eight long hours of working
On committees, schedules, talks,
It's hard to take an active part
If you're too "pooped" to walk!
You don't complain or criticize
But feel way down somewhere
It "ain't" right for some to say
You didn't really care.
So think it over members:
Is it really fair to all
To locate every *meeting place*
Where some can't come at all?

New 1978 IEEE Officers Announced

Election results for 1978 officers have just been announced by the Institute of Electrical and Electronics Engineers, IEEE, the world's largest engineering society. The President will be Dr. Ivan A. Getting, President of Aerospace Corporation.

He defeated Mr. Irwin Feerst in the third contested election held by the Institute. Dr. Getting will succeed Dr. Robert M. Saunders, Professor of Electrical Engineering at the University of California - Irvine.

Elected Executive Vice President is Dr. C. Lester Hogan, who defeated Mr. Carleton A. Bayless for this office.

Donald T. Hess, Chairman of the Tellers Committee of IEEE, announced that the new incoming president had received 28,161 votes and Mr. Feerst received 21,753 votes.

The incoming Executive Vice President received 24,793 volts. Mr. Bayless received 24,644 votes.

There were three Constitutional amendments on the ballot.

Proposition One, which calls for submission of all board-nominated candidates for office by May 1 of each year and all petition candidates by June 1, instead of July and August as now specified, received 40,197 votes in favor, or 79 percent, and 7,852 votes opposed, or 16 percent. It passed.

Proposition Two, which proposed changes in the Regional representation of the Board of Directors so that there will be seven geographical Regions, six of them in the United States, and the seventh comprising all other areas, did not carry. The votes were 21,337 in favor or 42 percent, and 26,924 opposed, or 53 percent.

Proposition Three, which provides for concurrence of any dues or assessment increase by a simple majority vote on a ballot to members, did not carry. The votes were 27,733 in favor, or 55 percent, and 21,492 opposed, or 42 percent.

Others elected to IEEE offices included the following:

Director of Region 1, Northeastern States, Dr. James E. Shepherd, a Computer Applications and Communications Consultant.

Director of Region 3, Southeastern States, Mr. Roy H. Harris, of Western Electric Company, Inc.

Director of Region 5, Southwestern States, Professor Darrell L. Vines, of Texas Tech University.

Director of Region 7, Canada, Mr. E.F. Glass, of Westinghouse Canada, Ltd.

Director of Region 9, Latin America, Mr. Carlos Rivera- Abrams, of Puerto Rico Water Resources Authority.

Divisional Directors, representing groups and societies, elected include the following:

Division I, Dr. Robert E. Larsen, of Systems Control, Inc.

Division III, Professor Mischa Schwartz, of Columbia University.

Division V, Dr. Richard E. Merwin, of the U.S. Army Ballistic Missile Defense Program Office.

Division VII, Mr. Walter F. Fee, of Northeast Utilities Service Company.

Predicting and Influencing Organizational Decisions

by
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All of us have observed organizational decisions that did not seem to make sense. I'll never understand how they chose that blankety-blank" is a frequently heard exclamation of exasperation. In many instances the speaker has just found that his prediction of what the choice would be was wrong, and consequently so was his planning. In other instances he has found that the alternative that he fought for was not the one selected by the organization. In either case, the outcome includes disappointment and a loss of resources and momentum.

The purpose of this paper is to closely review some of the factors that determine organizational decisions. Hopefully with an increased understanding of how such decisions are made, we will be more effective in predicting and in influencing such decisions. Increased ability to do either will make us more useful to our associates and will tend to further our own career goals as well. In particular, the paper reviews some strategies, some particular actions, that we can use to cause what we view as the best alternative to be the organization's choice.

There are, of course, many determinants of organizational decisions. In this paper we will discuss five of the more important ones. Each of them satisfies the following two criteria: (a) they have been the object of at least some empirical research, and (b) they lead to operational strategies. Let us begin.

1. Availability of Conspicuous Alternatives

A good deal of research demonstrates that alternatives that are close at hand or are conspicuous in the minds of the decision maker are very frequently chosen[1,2], more frequently chosen than their nature generally merits. This follows from the fact that most people and organizations undersearch for alternatives[3,4] and, instead, oversearch for information to bolster their relatively uninformed choices[5]. If this were a paper on how to improve our decisions, we could obtain no better advice - based on many research studies - than to search more extensively for alternatives than we think necessary. The fact of the matter is that we and our organizations tend to be lazy searchers and do not, as we should, view search as an investment[6].

Fifty years ago a piece of advice frequently given to young men beginning their careers in business was "Son, get a desk near the president's office." In those days, men drew on experience and observation to come up with this insight, an example of what research has since shown us to be a much more generalizable phenomenon: decision makers tend to select the conspicuous alternative.

Given this fact, how can we use it to further the objectives of our organizational unit or ourselves? Well one strategy is to make sure our favored alternative, e.g., our product or ourselves, is conspicuous. The tactics with which this is to be done cannot be usefully discussed here, as the particular approach for making something conspicuous must be specific to the situation. But one point should be made and this is that in many situtations by the time we or our unit rally ourselves to forcefully put forth our alternative, it will be too late - the decision will have been made. We cannot afford to be only reactive. In many settings we must also be proactive. For example, we cannot always wait for an RFP before making a customer aware of our products or talents, since in many cases the buyer's choice will have been made before the RFP is written. We must cause our favored alternatives to be conspicuous in the minds of people who might be making decisions in the future. That, of course, is what mass media advertising is all about - future purchases. We should note here that, especially in less formal decision situations, a "decision" in many respects is simply the near-random intersection of a problem looking for a solution and a solution looking for a problem[7]. What we need to do is to make sure that our favored alternative is one of the more active and pervasive solutions that are out there looking for problems.

We must sound a second note of caution here. There are undoubtedly circumstances were conspicuousness becomes abrasive or pushy, and while we may gain our end in the short run we will damage our relations with the decision makers in the long run. Again, the exact tactics to be used depend on the situation. One approach seems to be to make people generally aware of your alternative and then make them particularly aware of it near the time that the choice is to be made, assuming that the process signals you that the choice point is near. Certainly it is safe to say that inconspicuous alternatives seldom get chosen, and so we should do what we can to make sure our favored solutions are not inconspicuous.

All right, you say, I've got the message and I'm smart enough to figure out how to implement it, but what if we know that the decision maker has already begun to focus in on some other alternative, one that is not the one we think should be chosen? How can we complete? How can we overcome the effects of this near-law when it is working against us? These are important questions. They can be answered. We will be better able to answer them, however, after we have reviewed some of the other determinants of decisions. So let us set these questions aside for a few paragraphs and agree to pick them up again when we are more familiar with a wider set of factors affecting organizational decisions.

2. Time Available for Making the Decision

In general, decision makers try to solve their problems with old "tried and true" solutions[8,9]. "Off-the-shelf components" that have served well in the past are the ones rationalized as fitting today's new problem. Or sometimes it's simply the component that has been around a long time, or maybe it is the new shiny one. This approach is frequently used because it minimizes the time required for (hopefully) dealing with the problem.

As you can tell, we are again highlighting the importance of conspicuousness, for whatever reason - past performance, duration of availability, or newness of arrival. But this introduction is not our main point. Our main point is that the time available for making the decision is an extremely powerful determinant of how much information is sought[10,11]. This is especially true with respect to information concerning the availability of alternatives. If there is little time available, whether due to deadlines or workloads, there will tend to be very little search for alternatives[12]. Thus we can predict that in a situation where time is short, readily identifiable or available alternatives will have even a greater tendency to be chosen. Assuming that we know which possible solutions are conspicuous, and our experience and confidants will usually let us know this, we can be good predictors of organizational choices when the time for decision making is quite limited.

While, in general, we do not want decision makers to be rushed, a need for haste does increase our ability to predict outcomes. It also can cause our favored solutions to be adopted if they are in the more conspicuous set. Thus, if we know that the alternative that we think is the best one is also "in the lead," then we should not do anything that would lengthen the time used to make the decision. Instead we should attempt to do, within the bounds of ethics, good taste, and our future relations with the people involved, what we can to cause the decision process to come to closure.

3. Relative Ambiguity Associated with Various Data

When decision makers use information, they do not use it uniformly. Some information has a greater impact than does other information[13]. Reseach shows that hard data has a greater effect than soft data, that unambiguous data has a greater impact than ambiguous or less interpretable data[14]. Consequently we can asume that, all else being equal, the solutions that score high on criteria where there is hard data will tend to be selected over solutions that score high on soft data[15]. Of course it is true that other factors affect the relative importance of data besides their relative ambiguity. Nevertheless, the ambiguity associated with potentially key data can be an indicator in forecasting organizational choices.

How can we use this knowledge, that ambiguity is a determinant of decisions? A number of strategies can be used. One is to make sure that our favored alternative looks as good as it possibly can on the quantitatively assessed criteria. Another that should not be overlooked, if it is reasonable, is to challenge the relevance or usefulness data sets in which our product or proposal does not score well. Finally, if time and additional search for information will reduce the ambiguity associated with criteria which favor what we see as the best alternative, then we should encourage the expenditure of that time and search effort. Again, of course, this must all be done within the bounds of professional ethics and good taste.

This issue, that criteria are weighted in part by the ambiguity associated with the relevant data, has applications for the role of organizational politics in decision making, so it seems timely to turn now to the important subject.

4. The Influence and Interest of Powerful Persons

We all know of situations where what seemed to be the best solution on technical or economic grounds was not chosen for what seemed to be political reasons[16,17]. And we all know of cases where the technical and economic arguments either overcame political arguments or seemed to be the only arguments considered (but of course these never get written up in the journals). For our purposes in this paper, we are interested in being able to predict when nonpolitical criteria will dominate the decision and when political criteria will dominate. Armed with this knowledge, we will be better able to predict the outcome of the decision process and be better able to choose our strategy for affecting it.

A mistake that is frequently made in attempting to predict or affect organization choices by diagnosing or impacting the attitudes of powerful persons is to assume that they are (a) interested in solutions to the problem, and (b) willing to use their influence. These do not make it. Powerful persons are usually involved in many issues, and the problem that is of paramount interest to us may not necessarily be of paramount interest to them. In addition, organization power is a scarce resource, and while use of it sometimes creates more of it[18,19], overuse sometimes merely dissipates the reserve[20]. There are very few people who are willing to use their power in every instance that comes along. If we are counting on someone's influence to aid our cause, we must make certain they are interested enough to use this influence. Many who assumed that such assistance was forthcoming have been disappointed. We have heard them - "Boy, did he ever let us down," or "They let me climb out on the limb and then sat back and watched while those !?/X's sawed it off." That's not the way everyone saw it of course. The powerful person who was counted on saw either that he had other issues that were more critical or that he would be better off conserving his influence to use in another battle, and there are always those.

Now that we have a better understanding of when organization power might be used, we should consider when it will be effective. The answer to the question of when political criteria will dominate economic and technical criteria hinges to some extent on the concept

of ambiguity. If the "scores" for the various alternatives are such that it is unclear which should be chosen, i.e., there is ambiguity on the nonpolitical criteria, then the setting is ripe for power to dictate choice. If on the other hand, the balance or role of power is ambiguous, then nonpolitical criteria tend to dominate. The balance or role of power will be ambiguous when (a) equally powerful coalitions support different solutions, (b) the powerful persons appear uninterested or unwilling to exert influence, or (c) the situation is such that the use of or capitulation to power would be highly visible and would violate organization norms.

Some of the strategies that follow from the above remarks are obvious. For example, if our favored alternative appears to score well on economic or technical criteria, then we might try to minimize whatever ambiguity there might be in the scores and try to get closure before political criteria can be brought to bear. Or, if our cause has a powerful enemy, we might try to counteract him with powerful friends. Some of the strategies, though, are a bit more subtle. For example, we might take steps to reduce the interest of the powerful enemy by dragging out the decision process until he is occupied elsewhere, or by satisfying his principal concern. Or, we could take steps to make the use of power be a violation of organization norms by appealing to codified procedures, past practices, professional ethics, or whatever else seems reasonable.

Before leaving this important set of strategies, let us mention two strategies that can be very effective when attempting to diminish the power of someone opposing the adoption of what we see as the best solution. One of these is to simply restrict the use of power by making the decision process more public. Publicity is not the friend of politics, especially where organization norms lean toward the use of economic and technical criteria. Thus we might agree to publish the minutes of decision making meetings, review committee progress with superiors, or bring in neutral but decision-relevant observers. The second strategy is to dilute the power by enlarging the decision making group and push for essentially a one-man, one-vote decision or advisory rule. These two strategies have the added advantage of reducing the level of conflict, in general, a goal to be striven for by anyone involved in an ongoing organization.

5. Availability of Resources

Anyone knows that the limitation on the resources available allows some alternatives to stay within the feasible set and causes others to be eliminated. And of course it is good common sense to try to fit our alternative to the resource constraints and/or, if the situation demands it, to try to design or redesign the constraints to fit our alternative.

Although this is an important fact of organizational life and although these are useful strategies, we need instead to spend some time examining some of the more subtle implications of resource limitations.

One of these is that when there is an adverse change in the equilibrium relationship between resources and problems or the same resources and more problems, then the competition for resources to solve problems increases[14]. This leads to increases in organizational conflict and drives the decision making mode away from the use of problem-solving processes and toward the use of competitive strategies like bargaining and politiking[1], strategies that increase the propensity for the use of power. Thus for predictive purposes, we can say that with an adverse change in the resource-problem equilibrium, we would expect to see power play a more important role in decision making.

Another subtle implication of resource limitations is that if our favorite solution to the problem exceeds the resources available for solving the problem, this may indicate that our solution is "large enough" to solve other problems that, together with the first, would justify the expenditure required by the solution. Thus a common tactic of vendors is to propose an expensive piece of equipment and then point out that it solves problems we did not know we had! Or at least it has "reverse capabilities" or "capacity to fit our growing needs" or expectations. To generalize this vendor behavior, we can say that a useful strategy is to highlight the fact that our favorite alternative is actually more like a portfolio of solutions that solve multiple problems, all of them important, and that in aggregate these problems justify the expenditure of the added resources.

Several paragraphs ago, in our discussion of the availability of conspicuous alternatives, we agreed to address the question of what to do when an alternative that we do not feel is the best choice is the front-runner, the most conspicuous. We have some answers now, from the intervening paragraphs. One is to extend the time available for decision making, so that other alternatives are likely to receive more extensive scrutiny. A second is to identify ambiguities in the data or logic supporting the conspicuous alternative. A third is to try to alter the distribution of power being brought to bear on the decision process. And a fourth is to cause the fit between the resources available and the alternatives under consideration to be altered in favor of the alternative we believe best, either by pointing out that it can fulfill more needs than the conspicuous alternative or that it is quite sufficient but not nearly as demanding on the organization's resources.

Let us summarize this paper. Assuming that we are competent and well-intentioned professionals, it is in the best interest of our own unit and our parent organization for us to be capable in predicting and influencing organizational decisions. There are a number of variables that are useful bases for carrying out these two tasks. Among them are (1) the availability of conspicuous alternatives, (2) the time available for making the decision, (3) the relative ambiguity associated with various data, (4) the influence and interest of powerful persons, and (5) the availability of resouces. This paper has attempted to suggest strategies that might be useful in employing our awareness of these various variables in order to predict and influence, within the bounds of professional ethics, good taste, and continuing relationships, organizational decisions.

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SHORT COURSES

Detroit Research Institute Short Courses

Problems in Reliability Testing
Southfield, Michigan, February 21-22, 1978

Product Reliability - Introduction to Weibull Analysis
Chicago, Illinois, March 6-9, 1978

George Washington University Short Courses

Introduction to Fault Free Analysis
Washington, D.C., January 30-February 3, 1978

Statistical Methods in Reliability: Application of Recent Development to Reliability Problems
Washington, D.C, January 30-February 3, 1978

Air Pollution Control Equipment Operation and Maintenance
Washington, D.C., February 22-24, 1978

Contact: Director, Continuing Engineering Education
George Washington University
Washington, D.C. 20052
(202) 676-6106

Technology Applications Laboratory, Seventh International Workshop, San Jose, California, March 6-10, 1978

Contact: L.R. Webster, Technology Applications Laboratory
1670 Highway A1A
Satellite Beach, Florida 32937
(305) 777-1400

Conferences

1978 Annual Reliability and Maintainability Symposium
January 17-19, 1978, Los Angeles, California

Contact:
B.S. Orleans
4501 Connecticut Ave, N.W.
Washington, D.C. 20008

The program will feature the following:

MANAGEMENT

Managers' Views of R&M

The opening session of the Symposium will bring together the Symposium Advisory Board - top level managers from government and industry - who will comment on the response of the R&M Community to the needs of top management. The panel will be encouraged to discuss successes and failures of the community and to indicate how assurance practitioners might better serve the needs of management.

Continuing with this topic, the Tuesday evening session will provide a unique opportunity for dialogue between the practitioners and Program managers. Differing from the usual, highly technical session in which assurance practitioners talk to each other, speakers at this session will be managers from military, industrial, and commercial organizations. They will discuss the impacts of the assurance technologies on their programs, describe associated problems and deficiences from their perspective, and suggest methods for improving the interplay between the manager and the assurance community. Discussion between the audience and the panel will be encouraged.

MOTIVATION

Several sessions have been arranged to treat approaches and factors that motivate R&M achievement. Special attention will be given to actual experiences in the use of various techniques. Included will be:

Life Cycle Cost (LCC)

This year's LCC session will review the application and implementation of LCC policies. Contractor experiences will be examined and analyzed and the effects of such factors as maintainability and logistics on LCC will be considered.

Reliability Improvement Warranties (RIW)

The RIW session will also emphasize actual experience with the concept. Broad Air Force experience with warranty procurements will be discussed in one paper, while another will document a case history of a TACAN RIW application. Long-term warranty contracts and data/reporting requirements will be the topic of other papers.

Product Liability

Several examples of liability cases will focus on the specific circumstances, the legal issues involved, and the outcome of the litigation. A wide range of product types will be covered in the several papers.

METHODS

Reliability Theory

Five recognized experts from the faculties of major universities will examine the mathematical theory of concern to the assurance technologist. Particular stress will be placed on mathematical concepts and approaches whose application can be of significant value to the assurance community.

Maintainability

In an effort to expand the coverage of maintainability at the Symposium, two sessions on the subject have been arranged. The first - Maintainability Methods - addresses the problem of fielding equipments with good maintainability characteristics. The session will provide insight into the team efforts required during the design process to enhance maintainability, and the activities required to produce a desired improvement in the characteristic. Methods for establishing requirements and for assessing fielded systems will be presented.

The second session will recognize the competitive pressures in the commercial product markets that are requiring greater emphasis on maintainability characteristics. Case histories from the transportation and business machine industries will comment on the efforts required to assure suitable maintainability achievement.

Operational Influences on Reliability

This session was arranged to focus attention on the reasons for the considerable differences between reliabilities exhibited in the field and during test. Authors will address such factors as on-off cycling and envrionmental stresses and will present quantitative data on the effects.

TUTORIAL

The popular structured tutorial sessions will be conducted again this year. Running in parallel with the regular sessions for two and one half days, the sessions will appeal not only to the relative newcomers to the field, but also to those seeking a refresher. Individual sessions will cover Basic Reliability, Reliability Applications, and Maintainability Basics. In addition, one afternoon will be devoted to a workshop on Design to Cost and Life Cycle Cost, while the final tutorial will address the Design of Experiments. **Note:** To assure an appropriate tutorial climate, the attendance at these sessions must be limited. Since our experience from recent Symposia shows that these are well-attended sessions, we ask that if you intend to participate in the tutorials, you so indicate on the Advance Reservation coupon.

Call for Papers

Thirteenth Pulse Power Modulator Symposium, Buffalo, N.Y., June 20-22, 1978 (Abstracts due March 10, 1978)

Contact: Mr. Leonard Klein
Palisades Institute for Research Service, Inc.
201 Varick Street
New York, New York 10014
(212) 620-3377

IEEE Canadian Conference on Communications and Power, Montreal, Canada, October 18-20, 1978 (Abstracts due March 1, 1978)

Contact: Jean Jacques Archambault
CP/PO 7507, Succ. "C"
Montreal, Quebec H2L 4L6
(514) 285-1711/12

Developments in Distribution Switchgear, London, Britain, November 20-22, 1978 (Abstracts due February 13, 1978)

Contact: Ms. Laura Christie
IEE Power Division
IEEE, Savoy Place
London, WC2R, OBL, Britain

Conference Calendar

Mar. 15-17	Simulation Symposium (11th) Tampa, Florida
Mar. 20-24	Subscriber Loops and Services Int'l Symposium Georgia Tech Sheraton Biltmore Atlanta, Georgia
Mar. 21-23	Industrial Applications of Microprocessors Sheraton Philadelphia, Pennsylvania
Mar. 22-24	Vehicular Technology Conference The Regency Hotel Denver, Colorado
Mar. 23-24	New England Bio-Engineering Conference (6th) College of Engineering University of Rhode Island Kingston, Rhode Island
Apr. 3-5	Computer Architecture Symposium (5th) Rickey's Hyatt House Palo Alto, California
Apr. 4-5	Rubber and Plastics Industry Tech. Conference Akron, Ohio
Apr. 4-6	Private Electronic Switching Systems Int'l IEE, London, England
Apr. 10-12	Acoustics, Speech and Signal Processing Camelot Inn Tulsa, Oklahoma
Apr. 10-12	SOUTHEASTCON Atlanta, Georgia
Apr. 11-13	Joint Railroad Tech. Conference Radisson Street St. Paul, Minnesota
Apr. 12-14	Electronics in Resources Management (Region 6) Hollywood Inn Alamogordo, New Mexico
Apr. 12-14	Pattern Recognition and Artificial Intelligence Nassau Inn Princeton, N.J.
Jan. 16-18	Integrated and Guided Wave Optics Salt Lake Hilton Salt Lake City, Utah
Jan. 24-26	Reliability and Maintainability The Biltmore Los Angeles, California
Jan. 29-Feb. 3	Power Engineering Society Winter Meeting Statler Hilton New York City
Feb. 2-3	4th Joint College Curricula Workshop in Computer Science and Engineering Orlando, Florida

Feb. 7-9	Laser and Electro-Optical Systems II Town and Country Hotel San Diego, California
Feb. 13-15	Aerospace and Electronic Systems Winter Convention (WINCON) Los Angeles, California
Feb. 15-17	Int'l Solid-State Circuit Conference Hilton San Francisco, California
Feb. 28-Mar. 2	Compcon Spring San Francisco, California
Mar. 1-3	Control of Power Systems Lincoln Plaza Hotel Oklahoma City, Oklahoma
Apr. 16-18	Region V Conference "Energy '78" Camelot Inn Tulsa, Oklahoma
Apr. 18-20	Internat'l Reliability Physics Symposium Town and Country Hotel San Diego, California
Apr. 20-21	Textile Industry Tech. Conference Atlanta Hilton Hotel 255 Courtland and Harris St. Atlanta, Georgia
Apr. 24-26	Electronic Components Disneyland, Anaheim, California
May 3-5	Pulp and Paper Industry Tech. Conference Atlanta Hilton Atlanta, Georgia
May 8-11	Offshore Technology Houston, Texas
May 9-11	Cleveland Electrical-Electronics Conference and Exposition Cleveland, Ohio Cleveland Convention Center 25th Silver Anniversary
May 9-12	Intermag (International Magnetics Conference) Palazzo dei Congressi Florence, Italy
May 10-12	Conference on Software Engineering Hyatt Regency Hotel Atlanta, Georgia
May 15-18	Cement Industry Tech. Conference Hotel Roanoke Roanoke, Virginia
May 15-18	Plasma Science Intern'tl Asilomar Monterey, California
May 15-19	International IEEE/AP Symposium and USNC/URSI Mtg. Adult Education Center University of Maryland College Park, Maryland
May 16-18	Aerospace and Electronics Conference (NAECON) Dayton Convention Center Dayton, Ohio
May 17-19	Circuits and Systems Intern'tl Symposium Roosevelt Hotel New York, N.Y.
May 17-19	1978 Carnahan Conference on Crime Countermeasure Carnahan House Lexington, Kentucky
May 23-25	Electro/78 Boston-Sheraton Hynes Auditorium Boston, Massachusetts
May 24-26	Symposium on Multiple-Value Logic Chicago, Illinois
May 29-June 1	Intern'tl Quantum Electric Conference (10th) Atlanta, Georgia
June*	Power Electronics Specialist Conference
June*	Recent Advances and Future Trends in Magnetic Discs
June 4-7	International Conference on Communications Sheraton Hotel Toronto, Ontario, Canada
June 5-8	Industrial Power Systems Dept. Conference Stouffers Cincinnati, Ohio
June 5-8	National Computer Conference Anaheim Convention Center The Disneyland Hotel Comp. Anaheim, California
June 5-8	13th Photovoltaic Spec. Conference Shoreham Americana Hotel Washington, D.C.
June 12-14	Intern'tl Symposium on Electrical Insulation Marriott Hotel Philadelphia, Pennsylvania
June 20-22	Intern'tl Symposium on Electromagnetic Compatibility Sheraton-Biltmore Hotel Atlanta, Georgia
June 21-23	Fault Tolerant Computing Toulouse, France
June 21-23	Machine Processing of Remotely Sensed Data West Lafayette, Indiana
June 26-28	Design Automation Symposium Las Vegas, Nevada
June 26-29	Conference on Precision Electromagnetic Measure Conference Center Ottawa, Ontario, Canada
June 27-29	International Microwave Symposium Chateau Laurier Ottawa, Ontario, Canada
July*	Nuclear and Space Radiation Effects Conference University of New Mexico Albuquerque, New Mexico
July 16-21	Power Engineering Society Summer Meeting Los Angles, California