IEEE EMC SOCIETY

The Product Safety Newsletter

Vol. 6, No. 2 March-April 1993

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Chairman's Message

Посещение Санкт-Петербурга

This March I had the opportunity to visit St Petersburg, Russia, (formerly Leningrad) as part of a six-man team conducting a series of business management seminars at various venues in the city. We had been invited by the pastor of a bilingual church in the city, whose contacts in the business all academic communities had convinced him that such sharing would be very helpful.

St. Petersburg itself is a beautiful city .The most cosmopolitan of Russian cities and arguably its cultural and business center, it has been the meeting of east and west in Russia throughout its history. The site of the city was a swamp less than 300 years ago when Peter the Great decided to build his city there. Peter was greatly impressed with western science, art and technology and he forcefully integrated as much as he could into his Russia. For instance, he employed western European architects to design and build his city, the core of which was largely completed by 1800.

The timing of our hip was interesting; the backdrop was one of change. We arrived as the Russian

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The Product Safety Newsletter

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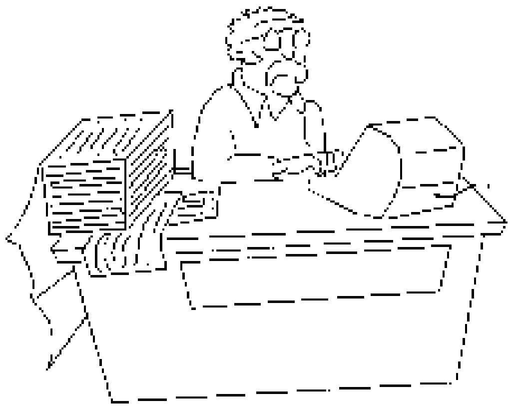
News and Notes



by Dave Edmunds
fax: (716) 422-6449

UL 1950 2nd EDITION
Underwriters Laboratories has issued 1950 2nd edition dated February 1993. This edition is based upon IEC 950 including amendments 1 and 2 and 33 Central Office Documents of IEC TC 76.

UL PRESENTS WORKSHOPS
UL has announced three 2-day workshops on topics of interest to Electronic and Electrical Product manufacturers.

1) "UL 1950" -a hands-on workshop to provide in depth information on evaluating products to comply with UL 1950.
2) "Globality: The Key to International Compliance" -to help manufacturers gain certification of their products by learning how to identify and meet requirements for products intended for sale in other markets. The seminar will focus on European countries, Canada, Mexico, Japan/Korea, Pac Rim and emerging markets.
3) "Plastic in Electronic and Electrical Products" - appliance manufacturers and others responsible for third party certification will learn how to streamline testing, select materials and the rating system for plastic materials. The focus will be on UL 94 and the UL 746 series.

For more information and details of dates, contact Laura Murphy at UL Northbrook Office, Phone (708) 272 8800, ext. 3402 or fax (708) 272 0919.

UNDERSTANDING THE EMC DIRECTIVE
The US Department of Commerce International Trade Administration, Washington DC 20230, has issued a paper explaining the EMC Directive status, conformance requirements, and what US manufacturers can do to comply.

An article in the Northeast Product Safety Society (NPSS) newsletter April 1993 also discusses the EN 45 000 series of documents.

STANDARDS NEWS
In the "CSA Info and Update" publication, they announced

Elec. Certification Notice No. 436E June 1, postponement of effective date to Gen. lnst. No. 5 for C22.2 No. 21-M1984, Cords sets and Power cords.

Elec. Certification Notice No. 521B Sept 30, publication of amendment to C22.2 No. 220-M1986, Information Processing and Business Equipment and revised direction of Elec. Certification Notice No. 521.

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Product Safeness As A Design Parameter

by Paul W. Hill & Associates, Inc.
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The following material is condensed from the text of "Product Safeness As A Design Parameter", 2nd Edition, 1990 by Paul W. Hill. The text is a registered copyright of Paul w. Hill & Associates, Inc. and is reproduced with permission. The book may be obtained by caning (407) 368 2538 or Fax (407) 368 0744.

The financial investment in products shipped, products in the distribution network and fin ished goods inventories simply can not be put at risk by the surfacing of product safety issues. Few profit margins can support a product recall, unplanned field fixes or basic redesigns to accommodate a safeness deficiency once tooling has been committed and production runs are underway. Latent safety issues in a product are real risks to its financial and marketing success.

Products obtain inherent safeness attributes by intentionally incorporating health, environmental and safety considerations in the product design process. Clearly, product safeness is a design parameter.

The material presented here is intended for those who develop or assist in the development of products, select the components and materials to be used, generate specifications and similar activities collectively called product development. Topics covered are those which have been the most difficult for developers of electrical, electronic and electromechanical products to appreciate and incorporate into the design, materials and components utilized in their products.

There are several reasons why product developers tend to have difficulty with product safeness requirements. It is not likely that engineers responsible for product development encountered product safety in their formal education or "on the job" activities in an instructive way. Few colleges and universities have organized instruction in product safety or regulatory agency equipment safety matters. In industry, some organizations sponsor seminars on the subject but the opportunity for product developers to participant is limited. There are product safety professionals in industry but their availability to serve in a teaching capacity is limited.

Industry standards and regulatory agency requirements for the safeness of products are generally the product developer's first encounter with the elements of safeness in equipment design. Well written as they may be, standards are not design guides, they are recipes for testing agencies to follow in the evaluation and certification of finished products. Standards do not offer much in the way of suggestions or viable options in the solution of safety design problems. Industry safety standards always lag behind technology and industry practices by some period of time which further diminishes their usefulness to product developers.

What appears to be needed is a much wider understanding of the reasonableness of safety requirements and the soundness of the engineering principles underlying the requirements being imposed. Experience has shown that once engineers come to appreciate the reasonableness of safety requirements and engineering principles supporting the safety requirements, they have much less difficulty incorporating safeness

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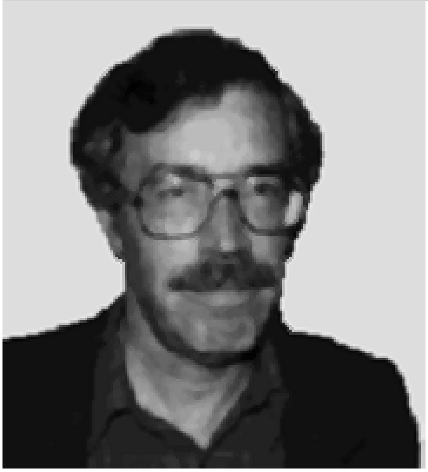
Technically Speaking



ELECTRIC SHOCK FROM RADIOS — A REVIEW

Copyright 1993 by Richard Nute

During the 1930's, 1940's, and 1950's, Under writers Laboratories did basic research in the field of safety and published the results of that research in a series of "Bulletins of Research." At least 58 Bulletins were published relating to fire,, explosion, and electric shock.

One of those Bulletins, "Measurement of Electric Shock Hazard In Radio Equipment," is a classic document in the field of product safety. It was written by Karl S. Geiges, an Associate Electrical Engineer at UL, as a thesis for a Master of Science degree. UL adopted Geiges' work into its "Standard for Power-operated Radio Receiving Appliances," and published the paper as a "Bulletin of Research, No. 33" in July, 1945. Geiges ultimately ascended to a vice-presidency of UL.

Geiges' paper is a classic because it originates the leakage current circuit and meter that many standards, not just UL, still use today. Geiges' circuit was used in ANSI C101, American National Standard For Leakage Current, until the 1992 edition.

INTRODUCTION

The basis of Geiges' study was the technological and competitive development of radio receivers following World War II. In 1945, all radios were two-wire products as grounding had not yet been implemented in the National Electrical Code. Leakage current was not drained by the ground wire as it is today. And double-insulation had yet to be invented.

"The development of radio receivers has followed a course somewhat parallel to that of other electrical equipment as far as shock hazard is concerned. From battery operation the change to a transformer design was a logical development because operation from alternating -current lighting circuits was desirable and the radio circuits could remain practically unchanged. The metal chassis was solidly connected to one side of the transformer secondary and was insulated from the line circuit by the primary-secondary insulation of the transformer. In some receiver designs a capacitor was connected between the chassis and the primary side of the transformer, but this filter arrangement employed capacitors of such small size that the ground current was of the order of fractions of a milliampere.

" As competition forced the development of new, less expensive receiver designs, new vacuum tubes were brought out and the so called "ac-dc" type of receiver was introduced. In this receiver, the transformer was

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Coated Metal Substrate Printed Wiring Boards

by Lal Bahra, P. Eng.
Canadian Standards Association

Coated metal substrate (CMS) printed wiring boards are currently being used in informa tion technology equipment evaluated to the requirements of CSA Standard *CAN/CSA* C22.2 No. 950, "Safety of Information Technology Equipment, Including Electrical Business Equipment", or IEC Publication 950.

Ceramic coated metal substrate printed wiring (PW) boards and other coated metal (i.e. coated with insulating compound such as epoxy resin, polyester, etc.) substrate PW boards are also being used in various industries. These PW boards, especially ceramic coated metal substrate boards, offer excellent performance and other advantages over conventional fibreglass/ epoxy boards.

Mechanical strength, excellent heat sinking capabilities, good ground path for fault currents when the metal substrate is connected to ground, and smaller sizes of components are some of the advantages of using CMS PW boards.

"Ceramic" Coated Metal Substrate PW Boards

For this type of CMS PW board a suitable metal or aluminum substrate is prepared by cleaning the metal thoroughly. A few thin layers of ceramic plus suitable bonding materials are then applied. The ceramic coating may also be directly electto-deposited onto the prepared metal. The assembly is then subjected to red heat, fusing the ceramic material to the metal substrate to provide a uniform coating. Copper is deposited and the assembly is again subjected to red heat. The PW board can now be prepared by optically transferring the pattern of the circuit and chemically etching away the unwanted copper. Components are secured to the board by utilizing surface mounting technology.

This method of preparing the PW board gives good handling properties to the board. As an assembly, it is capable of withstanding much higher temperatures than conventional PW boards.

"Insulating Compound" Coated Metal Substrate PW Boards

For this type of CMS PW board a few thin layers of compounds such as polyester or kapton etc., are deposited on the metal substrate by coating and then curing the assembly at a temperature that is considerably lower than the temperature necessary for red heat curing of ceramic coated boards. The manufacturer must employ quality control methods to control the thickness and temperature during the process. Pin holes may be present if the coating is applied only once. Several coatings need to be applied to achieve a uniform and suitable thickness, and to eliminate any pin holes in the coating material.

Hand Soldering and Repair of CMS PW Boards

Coated metal substrate PW boards must be carefully investigated if hand soldering is employed during assembly or repair .CMS PW boards are usually not subjected to hand soldering or repair. Defective units are returned to the factory rather than attempting to repair them in the field. Service instructions should caution the user against attempting repairs in the field. Any CMS PW boards having supplementary or reinforced insulation must not be subjected to repair. For CMS PW boards having only basic insulation, the acceptability of hand-soldering in making repairs re-

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CSA Gains NRTL Status

by Tom Tabor, P. Eng.
Canadian Standards Association

[CSA as a NRTL is news, just as UL acceptance in Canada is news, because it is another step on the path towards North American standards harmonization similar to the European Norms. A bi-national committee (including the PSTC Chairman Emeritus, Rich Pescatore) is presently working to harmonize UL1950 and CSA950. We asked both CSA and UL to describe what their new status will mean to regulatory engineers wanting certification for Canada and the U.S. - advantages and possible disadvantages, how submittal and certification processes would change, recognition by local authorities (e.g. -Province of Quebec, City of Los Angeles), plans for resolving problems, and so on. CSA has their say this issue, and UL next issue. Please write with your questions or comments! - Ed.]

The recent accreditation of the Canadian Standards Association (CSA) as a Nationally Recognized Testing Laboratory (NRTL) means that customers can now obtain convenient "one-stop" service from CSA to satisfy all of their North American certification needs.

Our formal accreditation by OSHA (the U.S. Occupational Safety and Health Administration) on December 24, 1992 makes CSA equal to other NRTL organizations with respect to regulatory acceptance: a product tested and approved by CSA to Canadian or U.S. standards has full regulatory acceptance throughout the U.S. and can be sold on both sides of the border.

For CSA customers, this eliminates the need for duplicate testing and evaluation, promotes a fast turnaround time in obtaining certification, and dramatically reduces follow-up inspection and frequency and cost. Manufacturers can therefore significantly reduce their costs and get their products to the North American marketplace more quickly.

The scope of CSA's accreditation covers a wide range of ANSI/UL standards, including all electrical and electronic products and equipment for the information technology, medical and telecommunications industries.

To further improve service and reduce duplication in North American product certification. CSA will accept test data and reports prepared by UL and other NRTLs. We will also accept components listed by UL and other recognized certification agencies.

BENEFITS OF CSA CONFORMITY ASSESSMENT

The recognition of CSA as a NRTL undoubtedly adds to the competition for customers among certification organizations. We have shown that we are fully prepared to work co-operatively within this marketplace, and we are committed to continuous improvement in overall quality, timeliness and cost of service.

Besides reliability and cost-effectiveness, we can emphasize CSA's long experience and stature as a world leader in both standards development and conformity assessment. Due to celebrate its 75th anniversary in 1994, CSA has established a network of offices and test facilities across Canada and around the world. In addition, we have developed reciprocal ties with conformity assessment organizations around the world. To deliver full and localized service within North America, we intend to follow our strategy of working in partnership with local independent laboratories, using local people. To that end, CSA is currently looking at increasing partnerships with independent laboratories in the U.S. and Mexico.

Our customers can also count on CSA 's reputation for both integrity and innovation. We are known for upholding the integrity of the CSA mark, which now appears on more than a billion products around the world, and for providing flexible and innovative programs that respond to client's needs.

In supporting CSA's application to OSHA, for example, CBEMA (the Computer and Business Equipment Manufacturers Association) comment that "CSA has been innovative in its approach to testing and certification without compromising its third party position of independence."

Hewlett Packard, which also supported CSA' s application, singled out CSA personnel as "knowledgeable, thorough and professional in their work," The average length of service for CSA staff is over 10 years.

Data General, a leading computer manufacturer, has publicly stated that CSA is "the most progressive, most helpful and most technologically advanced" of the many certification organizations it works with, as well as "the most customer oriented."

UNIQUE ADVANTAGES OF CSA SERVICE

Unique advantages we offer to customers include:

- just-in-time certification
- flat fee certification
- concurrent follow-up inspections on products and quality system through a co-operative arrangement with its subsidiary, the Quality Management Institute (QMI),
- The broadest product testing authorization under the CB Scheme of any testing laboratory in North America (a key benefit to North American manufacturers that export equipment).

ENHANCED RECOGNITION IN THE U.S.

The OSHA accreditation of CSA provides national recognition that enhances CSA's existing state and local accreditation in the U.S. CSA has been active since 1989, the year the Free Trade Agreement between the U.S. and Canada was signed, in seeking recognition at the state and local level through both formal and informal accreditation programs.

States such as Washington, Oregon, and North Carolina and cities such as Chicago, Boston, New York, and New Orleans have formally accredited CSA. In terms of informal recognition, CSA has established a vast network of regulatory acceptance through years of visits to all states, major cities and large municipalities. In areas such as New York City, the CSA mark has been recognized for over a quarter of a century.

COMMITMENT TO FREE TRADE

"One standard, one test, one mark" is a concept that CSA advocates wholeheartedly. CSA is committed to promoting the principles of *freer* trade, the development of harmonized standards, and the needs of customers on both sides of the border.

Products Certified to Canadian Standards Only

NRTL Products Certified to US Standards Only

NRTL/C Products Certified to US and Canadian Standards

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Elect. Certification Notice No.671 Sept 30, publication of amendment to C22.2 No. 950-M89, Safety of Information Technology Equipment, Including Electrical Business Equipment

Wires and Cable No.18, publication of C22.2 No. 49-1992 Flexible Cord and Cables.

Power Supplies No.1 March 31, Publication of C22.2 No. 234-M90 Safety Components Power Supplies.

For additional information phone CSA at (416) 747 4171.

IEC STANDARDS RELEASED

In the "ANSI Standard Action" it was noted: The following IEC Standards have recently been released:

IEC 227-1:1993, Polyvinyl chloride insulated cables of rated voltages up to and including 460/750V - Part 1: General requirements; Part 3: Non-sheathed cables for fixed wiring.

IEC 799: 1984/Amendment 1: 1993, Cord Sets

IEC 352-3:1993, Solderless connections- Part 3: Solderless accessible insulation displacement connections - General Requirements, test methods and practical guidance.

IEC 512-8: 1993, Electromechanical components for electronic equipment; basic testing procedures and measuring methods- Part 8: Connector tests (mechanical) and mechanical tests on contacts and terminations.

IEC 12204: 1993, Low-voltage power supply devices, d.c. output - Performance characteristics and safety requirements.

IEC 1010-2-031: 1993, Safety requirements for electrical equipment for measurement, control and laboratory use - Part 2-031: Particular requirements for hand-held probe assemblies for electrical measurement and test.

The following drafts on Acoustics have been sent to CEN members of enquiry and comment. Copies are available from ANSI at the price indicated.

prEN 24869-3, Acoustics - Hearing protectors - Part 3: Simplified method for the measurement of insertion loss of ear-muff type protectors for quality inspection purposes (ISO/TR 4869-3: 1989) - July 17,1993. $22.00

prEN 31201, Acoustics - Noise emitted by machinery and equipment - Measurement of emission sound pressure levels at the work station and at other specified positions - Engineering method in an essentially free field over a reflecting plane - July 25, 1993, $18.00.

prEN 31202. Acoustics - Noise emitted by machinery and equipment - Measurement of emission sound pressure levels at the work station and at other specified positions - Survey method in situ - July 25. 1993. $18.00.

prEN 31203, Acoustics -Noise emitted by machinery and equipment -Determination of emission sound pressure levels at the work station and at other positions - July 25, 1993, $18.00.

prEN 31204, Acoustics - Noise emitted by machinery and equipment - Measurement of emission sound pressure levels at the work station and at other specified positions - Method requiring environmental corrections (ISO/DIS 11204) - July 25, 1993, $18.00.

prEN 32001, Acoustics - Noise emitted by machinery and equipment - Rules for the drafting and presentation of a noise test code (ISO/DIS 12001) - July 25, 1993, $18.00.

Technically Speaking
Continued from page 4

eliminated, vacuum tube filaments were connected in series, and plate voltages were lowered to permit the use of rectified 120-v alternating current. Then the designer was faced with a problem. If the chassis were used as the negative return it would be connected directly to one side of the line. Any contact with the chassis that was made by the user, as in replacing tubes, would expose him to full line potential if the chassis were connected to the ungrounded side of the line.

"...The alternative that has been generally used is to employ an insulated negative bus within the chassis and, for higher frequencies, to ground the bus to the chassis through a capacitor of 0.10 to 0.25 µF. With such an arrangement, when the receiver is connected to a 120-v ac line the leakage current from chassis to ground is 4.5 to 11.3 mA."

These values, 4.5 to 11.3 mA, were calculated using the capacitive reactance equation to find the reactance, and then Ohm's Law to calculate the current. Geiges went on to say that leakage current could be controlled simply by controlling the maximum value of the line-to-chassis capacitance. However, to do so required:

- study of the schematic diagram to find the leakage paths;
- finding parallel leakage paths, if any;
- determining vacuum tube leakage current from heater to cathode;
- controlling voltages at accessible parts.

Rather than calculation of leakage current based on circuit analyses, Geiges believed that direct measurement of leakage current would be much more practical. Such direct measurement could be applied to most other electrical products, and would not be restricted to radios.

Interestingly, Geiges mentions that previous attempts to measure leakage current bad failed, that a measuring means was not available, and that serious difficulties would be encountered in any practical solution.

ELECTRIC SHOCK HAZARD

Geiges defined electric shock hazard as a circuit in which the body is a part of the circuit. He next defined the circuit parameters:

a. The voltage between the two points of body contact. This is important, he said, because the voltage breaks down the high initial resistance of the skin, and because the voltage determines the magnitude of the current in the body.

b. The frequency of the supply voltage. Geiges said that at high frequency there is less musculac reaction than at low frequency.

c. The capacitance of the source. Geiges said that the charge, in coulombs, is important. He didn't say why it was important.

d. The resistance of the source. This resistance serves to limit the current in the body.

Geiges said that current through the body has three major effects:

(1) involuntary muscular reaction,
(2) ventricular fibrillation, and
(3) tissue burns due to heating. Such currents are readily available from the operating voltages on equipment.

Geiges studied various research work to identify values of current for the threshold of perception (0.2 mA), let-go (8 mA), and fatality (100 mA).

Geiges especially noted Dalziel's work which concluded that let-go current is a function of the peak value, 11.3 mA, not the root-mean-square (rms), 8.0 mA, value.

From these parameters, Geiges concluded that the limits of current and voltage that needed to be measured were 1-30 mA ac, and 1-150 v, ac and dc, (household voltage) and 1-600 v, ac and dc (plate circuits of vacuum tubes).

BODY RESISTANCE

Geiges stated that the body is analogous to a resistor and capacitor in parallel. He said that the capacitance is very small and can be disregarded for power line frequencies.

Geiges studied Whitaker's work, and concluded that a body resistance of 1500Ω was "the best compromise for this investigation."

1500Ω "is slightly less than the lowest recorded value with dry contact surfaces, 1550Ω, and it compares favorably with average values obtained under conditions that existed in the case of the wet hands and feet."

"If a higher value is chosen it is difficult to justify in view of the 1500Ω dry value. A lower value offers equal difficulties in that a safety factor is introduced which will be added to the factor that should be considered in the determination of permissible leakage current."

"The body resistance was also considered from the low voltage hazard standpoint in arriving at the 1500Ω, value. A 15-v circuit would cause a current flow of 10 mA. If a resistance value similar to that used for the electric fence work by Whitaker (500Ω) were used in this case, a 5-v circuit would result in a 10 mA current and a 15-v circuit would result in a 30-mA current. Where indoor use equipment is under consideration, the 1500Ω, value appears to be lower than conditions would warrant, while the 1500Ω value can be justified in terms of conditions that it would be reasonable to expect in actual service."

SHOCK HAZARDS OF RADIO EQUIPMENT

In 1945, Geiges was faced with the same, classic operator-serviceman dichotomy we still face today. Geiges clearly sets forth the parameters, but we have continued the argument without resolution for 45 years!

"There is no definite line of demarcation between the class of persons who should and should not have access to live parts but a rather sharp distinction can be made in the reasoning that is involved in the action of exposing such parts. Repair and service work generally requires that parts be live while exposed for tests and adjustments. Qualified persons know that live parts will be exposed when covers held in place by screws and similar fastenings are removed, and that interlocks must be blocked in the "on" position to make the necessary tests and adjustments. However, an unqualified person knows that replacement of tubes, fuses, batteries, etc., is necessary and he expects to make such changes without the necessity for taking any precaution other than turning the single-pole power switch to the "off" position."

Geiges further noted that dc leakage currents were available from various parts of ac-dc radios. Many vacuum tubes were provided with metal caps for connection to the control grid element. The control grid was a source of dc leakage current. Even if the control grid was in a base terminal rather than a cap terminal, the stator of the tuning capacitor was normally accessible and was connected to a vacuum tube control grid and was therefore a source of dc leakage current.

METHODS OF MEASURING SHOCK HAZARD

Note that the values of leakage current that Geiges and others were attempting to measure were quite high compared to today's values. Geiges was attempting to measure leakage currents in the range of 4 mA to almost 13 mA, while today, we measure leakage currents in the range of 0.5 mA to, at most, 3.5 mA. With these high values of leakage current, the resistance of the measuring device, if significantly greater than zero, affects the measured value.

For example, if we assume a leakage current of 10 mA from a 120 volt source, then the resistance of the circuit is:

$$R = \frac{E}{I}$$

$$R = \frac{120}{0.010}$$

$$R = 12{,}000\Omega$$

If we insert a 1,500Ω resistor in the circuit, representing the body resistance, then the value of current would be:

$$I = \frac{E}{R}$$

$$I = \frac{120}{12{,}000 + 1{,}500}$$

$$I = 0.089 \text{ amperes or } 8.9 \text{ mA}$$

On the other hand, if we insert a 500Ω resistor in the circuit, then the value of current would be:

$$I = \frac{120}{12{,}000 + 500}$$

$$I = \text{O.O96A or } 9.6\text{mA}$$

Therefore, Geiges reported lack of correlation of leakage current data due to lack of a standard resistance for the measuring device.

For reasons given in the body-resistance discussion, Geiges chose 1,500Ω as the standard meter resistance.

Geiges then said, "The basis for evaluation of the severity of electric shock would be expected to involve muscular reaction."

Because muscular reaction and let-go phenomena are proportional to the peak value of ac current, Geiges wanted a meter that would measure a steady-state peak value.

Geiges then initiated a search for a suitable measuring device. In 1945, these were the common instruments of the time:

Electrodynamometer instrument.

Thermocouple instrument.

Rectifier (copper-oxide) instrument.

Vacuum Tube Voltmeter.

The "rectifier-feed, diode-peak" vacuum-tube voltmeter had the characteristics that Geiges had specified. In particular, it was sensitive to the peak value of voltage.

"The sine wave a-c reading is the most common reading made with a leakage current meter so that for simplicity it is desirable to calibrate the (peak-reading) meter to read the root-mean-square value of the sine wave."

With a resistor across its terminals, the scale could be calibrated in rms milliamperes, "thereby giving a direct measurement of leakage current."

'The result is a measuring device that is actuated by the shock hazard criterion—peak current—and the measurement is in terms of root-mean-square milliamperes when the current source is limited to an a-c sine wave. If a nonsinusoidal wave shape is to be measured, the scale reading is .707 of the maximum peak and the reading is a measure of the shock hazard."

The resulting leakage current measuring system was a peak-reading, rms-calibrated vacuum-tube voltmeter, which measured the voltage across a 1500Ω resistor. The value of voltage was divided by 1500 to give the value of the current through the resistor. The meter scale could include a current scale to avoid the calculation.

SHOCK HAZARD MEASUREMENT SPECIFICATION FOR RADIO EQUIPMENT

"Shock hazard shall be considered to exist at a live part in a circuit involving a potential of 125 v or less in the following cases:

"(a) At an exposed live part, if the open-circuit potential is more than 25 v and the current with a 1500-ohm load is more than 5 mA.

"(b) At a partially protected live part, if the open-circuit voltage is more than 35 v and if the current with a 1500-ohm load is more than 15 mA, with a maximum allowable a-c component of 10 mA in any case.

"A part is considered to be exposed if it is subject to handling in normal use (not servicing)... A part is considered to be partially protected if it is located within the overall enclosure or beneath the appliance so that contact by persons is unlikely."

DISCUSSION OF SPECIFICATION

"The specific current and voltage limits, although not directly connected with the design of the measuring device, are a part of the general problem and their origin is covered here for completeness."

"Open Circuit Potentials —Exposed live parts operating at potentials of 25 v and less are not considered hazardous unless the equipment is intended for use in a location that involves special conditions of moisture or body exposure. ...The higher voltage specified for partially protected live parts is based on the decreased likelihood of most favorable shock conditions... The use of 30-32 v for automatic tuning motors... has been common for years."

"Leakage Current — The 5-mA value for permissible leakage current is based on recommendations of shock investigators and past practice. It is well above the threshold of perception and is admittedly a current that will startle the person receiving the shock."

"The 5-mA current is believed to be low enough to permit release by the person receiving the shock."

"Exceptions — The size of small parts and the relative inaccessibility of the tuning capacitor may be used as justification for practices followed for a number of years in the radio industry, but it is difficult to reconcile this practice with shock hazard current limitations.'

Clearly, this was a landmark work. Reducing leakage current from the 10 mA range to less than 5 mA should have been a major re-design effort on the part of radio manufacturers.

To bring this into perspective 45 years later, one industry segment is proposing to reduce leakage current from 3.5 mA to 0.5 mA. If this proposal becomes effective, manufacturers again will face a major redesign effort.

Today, we continue to use the 500Ω resistor to measure leakage current. However, because we now work with much lower leakage current values, the voltage does not break down the high initial resistance of the body, so the body resistance is almost never as low as 1500Ω. (You can tell when the body resistance breaks down---it occurs simultaneously with the onset of the sensation of electric shock).

When Geiges was measuring 10mA leakage currents from 120V, the source resistance was 12kΩ. The 1.5kΩ resistor had 8 percent effect on the measurement.

With today's relatively low values of leakage current, the effect of the 1500Ω resistance on the measurement is negligible. For example, when we measure 0.5 milliampere leakage current from 120 volts, the source resistance is 240 kΩ. The 1.5 kΩ resistor has only 1.6 percent effect on the measurement.
We should not lose track of Dalziel's finding that let-go (and sensation, as implied by Geiges) is proportional to the peak value of current. Today, true-rms meters are common. They are not peak-measuring meters calibrated in rms. So, such meters when, measuring non-sinusoidal leakage Currents, will give a lower reading than would the peak-measuring meter.

ANSI C101-1992, Leakage Current for Appliances, reinforces Dalziel's finding that the body's physiological response to current is proportional to the peak value.

ACKNOWLEDGMENTS
Jim Pierce, Eng. Testing Laboratories, dropped a copy of this UL Bulletin on my desk, asking if I had read it. I had seen and read the Bulletin many years ago, so the copy just sat on my desk for many months. Eventually, I picked it up and started reading. I was impressed with the work, and thought I would review it for you.

Your comments on this article are welcome. Please address your comments to the Product Safety Newsletter, Attention Roger Volgstadt, *c/o* Tandem Computers Inc., 10300 N. Tantau Avenue, Location 56, Cupertino, California 95014-0708.

Product Safeness
Continued on page 4

factors into product designs. With any reduction of these difficulties product development costs will decline, development times are reduced, they get it right on the first pass and the inherent safeness of the end product will improve. Clearly, product safeness is a design parameter.

There is a challenge in all this to practitioners of the safety profession, namely, they must understand these principles and the underlying engineering rationale well enough to communicate them to those in the engineering and product development community.

ELEMENTS DRIVING PRODUCT SAFETY

Demands and requirements placed on a product, such as product safety, should have some justification for the costs to the product and for the resources required to implement them. In the case of product safety several justifications can be made.

Safety related legal conditions.

Most countries in the industrialized world have binding legal requirements that mandate safety certification before a product can be imported or sold in the country. Safety compliance is demonstrated by evaluation by a recognized testing agency. If the product is acceptable it is authorized to display the test agency logo or monogram. In the United States equipment certification is referred to as “listed”. Similarly, safety sensitive components and subassemblies are “recognized”.

Therefore, the first justification is to have a product which is legally permitted to enter into commerce.

Risk of safety related litigation.

Litigation requires the expenditure of resources should a charge or claim against a product be made, regardless of the merits of the claim. Time and expense is involved in investigations, retesting, simulating various faults, design reviews, legal fees and other tangible and intangible expenditures. Some litigation costs may never be recovered such as lost revenue if product distribution is curtailed, lost market share as customers react to litigation disclosures and expenses necessary to recapture lost market position. It may not be possible to avoid all safety related litigation actions against a product. However, it is possible to design a products that incorporates recognized safeness attributes so as to readily defeat unreasonable safeness claim against it.

It follows that the second justification is the protection of the investment made in the product and its market position.

Market forces.

Once a level of safeness for a product is established in the market place, consumer expectations are correspondingly set. Competing products must be perceived to be at least as safe as others in the same market. The level of safeness established in a market may well exceed that required by industry standards. Competing products must be perceived by consumers to be keeping pace. Clearly, consumer expectations justify at least a competitive product safety position.

Market expansion.

Often an established product has the opportunity to expand into new market areas. For example, a commercial device can be adapted for use in hospitals or a North American product can find profitable markets in Europe. Most market movements will require safety certification activities and possibly design changes to comply with safety requirements in the new market area. Positioning a product for expansion into wider regional or global marketing is yet another justification for considering safeness in the design of a product.

Other elements may also drive product safety considerations but these four are the most compelling reasons to commit resources for incorporating safeness attributes into the design of a product.

HOW SAFE IS SAFE ENOUGH?

There are four basic parameters for determining an acceptable minimum level of safeness for a product. These parameters address the intended end use, elimination of latent hazards, product certifications and acceptability of residual risks.

Intended use and foreseeable misuse.

The first element of product safeness is reasonably obvious, products must be safe for their intended use.

Intended use are those usages and conditions for which the product was designed and designated by the manufacturer. These include installation, operation and service functions. The manufacturer or importer must define these activities and the limits of each in the operating and service instructions.

Misuse is considered to be those uses to which the product can be put, but go beyond the intent of the designer or manufacturer. Such usage which can reasonably be foreseen in advance is called foreseeable misuse. For example, a screw driver is intended to provide torque to a slotted and threaded fastener device such as a screw, lug or the like. Yet screw drivers are commonly used as a lever, pry, and wedge all extensions of the original intent.

A word of caution is in order concerning misuse. Designers can not assume a "user beware" attitude. The designer is expected to consider foreseeable misuse possibilities and provide for an acceptable level of safeness should foreseeable misuse occur.

Latent hazards.

Consideration of latent hazards is important because of exposure in litigation actions in which the issue centers on whether the manufacturer "knew or could have known" hazards were inherent in the product or its usage. Latent hazards are identified by a process called fault testing. These tests are conducted so as to expose potential hazards in operation and servicing which may not have been considered in the design objectives or detected by traditional product evaluations, quality control activities or manufacturing tests. The tests involve physical inspections, real time operation, servicing activities, and adequacy of instructions provided with the device. The intent is to determine the degree of protection provided by the equipment should a hazard be encountered.

Fault testing is not to be confused with worst case testing. Worst case testing is primarily performance oriented and addresses performance capabilities under extreme operating conditions. Fault testing examines the various ways operators and service personnel might encounter hazards, and the ability of the product to provide reasonable protection against such hazardous encounters. For example, utilization of power outlets with inadequate or no earth grounding, unauthorized servicing of parts easily accessible with common tools, disposal of consumables containing toxic materials, and similar situations. These hazards can easily escape quality controls, worst case testing and even testing by safety certification agencies.

Product certifications.

Most industrialized countries require products to be safety tested. There are few exceptions. Even OSHA requires testing for safeness by the manufacturer even if formal listing or approvals are not pursued, such as one of a kind, customized or very small volume production of a product. As evidence of compliance the testing agency authorizes the display of their logo or monogram on the product. It is generally viewed as a marketing necessary for widely distributed products and might carry several monograms such as CSA, UL, TÜV, SEMKO, and others.

The safety standards used for certifications will depend on the product marketing areas. In the United States many major safety standards are generated by Underwriters Laboratories (UL), some of these are also American National Standards Institute (ANSI) publications as well. In Canada the Canadian Standards Association (CSA) issues similar safety standards. Outside North America the major product safety standards are generated by the International Electrotechnical Commission (IEC). In the less industrialized countries the IEC standards are generally recognized and accepted. In South America, UL, standards are widely accepted. Major differences between product safety standards generated by UL and IEC are being reviewed in an attempt to harmonized standards. However, many differences are likely to remain and standards from both organizations must be considered for products globally marketed.

Residual safety risks.

Residual risks are those safety issues which remain in the product when final product evaluations are complete and certifications obtained. These may be safety concerns not covered by safety standards, unsatisfied safety design objectives or certification oversights, (i.e. see introduction or forward of product safety standards for disclaimers test agencies make for safety testing of products). There may be inadequate safety margins to compensate for manufacturing variances and parts supplier variability. There may also be safety concerns discovered in fault testing.

Proceeding to market the product requires either corrective actions or acceptance of the risks in the product as it is. It is the responsibility of senior management to consider all the factors involved and make the decision to correct the safety concerns or accept the residual risks. In many organizations this management process is a formal safety review by a group representing engineering, manufacturing, marketing, quality and legal counsel. The importance of this process reflects back to the concept of "knew or could have known" of safety concerns mentioned above.

These are the four major factors in determining the minimum safeness of a product. Many organization go further and use safety reviews by a third party consultant and use internal safety standards to supplement deficiencies in industry standards. Some include health and environmental considerations as well as personal safety and property damage in product safeness evaluations. These issues are discussed in later sections on toxic materials and the need to design beyond the requirements of safety standards.

Coated Metal...
Continued from page 3

quires investigation.

Compliance

Many end product standards do not contain requirements for evaluating CMS PW boards. For the purpose of determining suitability of such PW boards in an end product, a sample assembly of a CMS PW board used in the product should be subjected to the thermal cycling, thermal aging, dielectric strength and abrasion resistance tests of Clause 2.9.5 of CSA Standard *CAN/CSA-C22.2* No.950 or mc Publication 950.

Requirement for Basic Insulation on CMS PW Boards

There is no thickness requirement in IEC Publication 950 for basic insulation. Acceptance is based on compliance with dielectric strength test requirements following normal and abnormal tests, thermal cycling, thermal aging and abrasion resistance tests. If the metal substrate is connected to ground, clearances and creepage distances on the CMS PW board must be in compliance with the requirements of the applicable standard. See attached Fig 1 which illustrates a CMS PW board with the metal substrate connected to ground.

Bond impedance and limited short circuit tests should be conducted, as applicable, in accordance with CSA Standard C22.2 No 0.4, Bonding and Grounding of Electrical Equipment (Protective Grounding). If the metal substrate of a CMS PW board forms part of the product enclosure then it is subject to mechanical tests such as impact and steady force that are applicable to the enclosure in additional to normal, abnormal and thermal tests.

Servicing of products utilizing basic insulation on CMS PW boards should not result in the reduction of

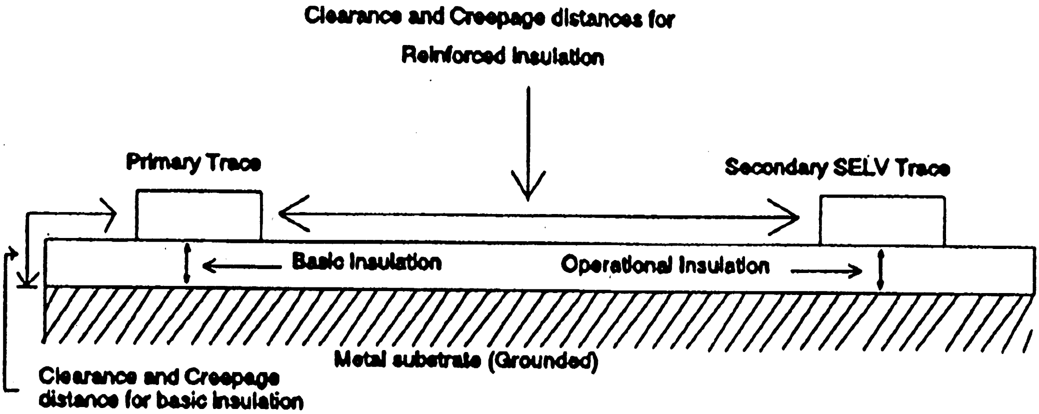

Fig 1

CMS PW board with metal substrate connected to ground

clearances, creepage distances and pollution degree.

Requirements for Supplementary and Reinforced insulation on CMS PW Boards

In general, for the type of construction utilizing supplementary and reinforced insulation on CMS PW boards, the metal substrate is located inside an insulating enclosure and must not be connected to ground (i.e. the metal substrate is floating).

The minimum thickness requirement for supplementary and reinforced insulations in IEC Publication 950 is 0.4 mm. It might first appear that CMS PW boards cannot meet these requirements for supplementary and reinforced insulations as the insulation on a CMS PW board is only a few microns thick. In this case, however, there is the option of using two thin layers as there is no thickness requirement in the Standard for insulation in thin layers. Only electric strength test requirements have to be met.

During the preparation of “insulating compound” coated metal substrate PW boards, several coats of insulating material are applied to avoid pin holes and achieve a uniform thickness. Although these individual layers or coatings cannot be evaluated on an individual basis as specified in the standard, they can be evaluated collectively by considering the total thickness as being equivalent to two layers and applying an electric strength test for the appropriate grade of insulation (supplementary or reinforced) using a test voltage that is twice that for the single layer.

Fig 2 shows the cross-section of a ceramic coated metal substrate PU board with a primary and second-ary trace, where reinforced insulation is required. This assembly is acceptable provided the criteria described in (a) through (g), as applicable, are met.

a. Required clearances and creepage distances for reinforced insulation are maintained between primary and safety extra-low voltage (SELV) secondary traces on the surface of the CMS PW board. From primary trace to the edge of the metal substrate, the minimum

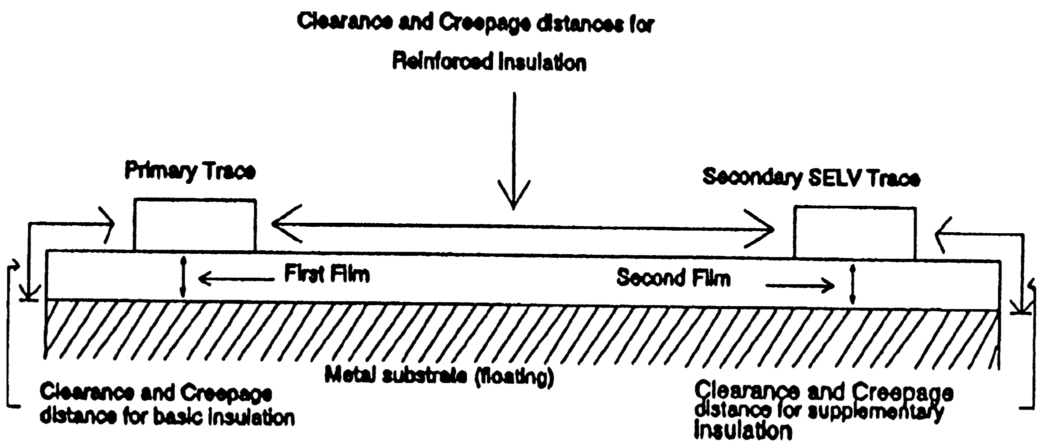

Fig 2

Evaluation of CMS PW board insulating compound as reinforded insulation. When Metal substrate is floating

clearance and creepage distance required for basic insulation must be maintained. From SELV secondary traces to the edge of the metal substrate, the minimum clearance and creepage distance required for supplementary insulation must be maintained. The metal substrate is considered to be intermediate metal and clearance and creepage distances are still required for supplementary insulation from SEL V secondary traces to the metal substrate.

b. Insulating material meets flame test classification V-1 or better and is heat and moisture resistant.

c. As illustrated in Fig 2, two thin films of insulation are provided between primary and SELV secondary circuits the first thin film being the insulation between the primary trace and metal substrate and the second thin film being the insulation between metal substrate and the SEL V secondary trace. The insulation between all traces and metal substrate must be able to withstand the dielectric voltage withstand test for reinforced insulation after normal and abnormal tests, thermal cycling, thermal aging and abrasion resistance tests.

d. The raw metal substrate PW board with copper deposit before processing (i.e. chemical etching) meets the dielectric strength test for basic insulation, as a production test.

e. For components mounted to the CMS PW board by surface mounting technology, the effect of components coming off and reducing any clearances or creepage distances during abnormal operating conditions is determined. For example, a component mounted by only 4 pins or less, must be investigated by conducting fault testing which would result in highest temperature.

f. Servicing instructions clearly indicate that CMS PW boards must be replaced and not repaired.

g. Periodic testing of the CMS PW boards is conducted when it is necessary to ensure compliance on a continuous basis.

Continued from page 1

winter was beginning to turn to spring. The Neva River, which divides the city, was still covered with ice but clearly was beginning its thaw (when we left it was mostly free of ice). Boris Yeltsin was facing the most severe test of his leadership and there was an air of nervous caution. Even though most political events were being staged in Moscow, the broad evidence of change was clearly displayed in St. Petersburg.

My personal goal for the trip was to spend as much one-on-one time with Russians as our seminar commitments would permit. We worked in as many private meetings with businessmen, educators, civic leaders and technologists as we could. We stayed in a typical apartment rather than at a hotel. Our logistics were coordinated by young Russians, all in their early and mid-twenties, with whom we spent almost all of our time. My translator, an engineering student in his final year in his university studies, was with me 12 or more hours a day, as were our other translators. We formed close friendships there, friendships which I believe will be lasting.

Probably the most important observation I can share is that one must be very careful in making generalizations about Russians and their country; the "average Russian" can be just as difficult to characterize as the "average American". While Russians are more culturally homogeneous than Americans, there is much more individual diversity *within* each of our societies than there is *between* the two. I found this particularly true of younger Russians and is especially apparent when individual Russians are in more private settings and away from their usual circles.

In some ways. the overall environment could be compared to "post-war reconstruction" without the benefit of either a clear victor or evidence of physical "devastation". I found some characteristics that brought to mind our own "wild west" or Chicago in the twenties with a little post-WW1 Germany thrown in for good measure. Inflation is quite severe and many people will immediately exchange their rubles for almost anything...bus tokens, clothing, anything...their buying power is seemingly being eroded each day. Many people, especially among the young, are running all sorts of businesses on the side in attempts to improve their situations.

The impact of Russia's conscious change in direction from a centrally controlled, defense- and government-oriented economy is enormous. Seventy years of socialist tradition has clearly left its impact and the change to a market economy has more than its share of challenges.

Not surprisingly, the most resistance to change often seems to come from those who believe they have the most to lose. And while the Russian leadership is grappling with monumental changes such as decentralization and privatization of property and industry, the old infrastructure and bureaucracy are struggling to keep up, sometimes without great success. Put yourself in the place of a middle manager with twenty years in government service or in a state-owned industry. You've spent your career responding to central control, focused on the supplier side, where higher authority established much of your work reality. Your society and economy has seventy years of this inertia. Now, your focus must abruptly and radically shift to the market side even while ownership and the very nature of your business and its future is being decided by others. I imagine that many of us, including those in the US automobile or defense industries, in spite of our traditions of the free market, decentralized control and an advanced infrastructure, can empathize.

The exisiting infrastructure in Russia is not well geared to both support these changes and facilitate rapid progress. For instance, consider the state of communications. We recognize our need to continually push the practical technological limits to enhance efficiency of our communication infrastructure to survive in the global economy. In contrast, while citizens of St. Petersburg can get MTV on their televisions and there's evidence of cellular phone networks in operation, the basic phone system is quite dated and communication with those outside the country can be very frustrating and requires considerable patience. Mail sent into Russia from outside the country takes weeks or even longer to be delivered, if it arrives at all.

There are also "intangible" aspects of the infrastructure that don't readily support the change to a freer, global market-oriented economy. In the US and elsewhere there has been a prevailing attitude of trust, fairness and respect for a fair profit in commerce. In spite of embarrassing instances of white-collar crime in business, we are able to conduct our business efficiently based on a foundation of expected ethics and standards of conduct. However, to many Russians, profit is immoral and is evidence of crookedness; even the term "businessman" can evoke a negative connotation. Also, I found acknowledgment that basic trust in others (outside your small circle) was much less common than here; in fact, personal trust has been a precious commodity.

While I don't want to minimize the challenges that face Russia and the frustrations in trying to do business there, I found St Petersburg exciting and fascinating. Conventional Western wisdom says that China is the emerging super-economic power and the better choice for future ventures, at least for the next two decades. However, the potential in Russia appeals to my senses. The young people are better educated and probably better balanced than we are, all things considered. They recognize the relative spiritual and ethical vacuum in their country better than we do ours. Though they are becoming more materialistic, they are not nearly as self-absorbed and selfish as we tend to be. In our country, we squander talent by individual choice; in Russia, the talent has historically been restrained and rechanneled by others. As a people, they have repeatedly demonstrated their incredible survival instincts in spite of extreme hardships.

With regard to their individual and collective future, I found quite a diversity of opinion and individual differences among the Russians we met I imagine that many will become impatient with slow progress and be tempted to leave their areas of technical and professional expertise to go into commerce, where more money can be made today. There was evidence that enterprising young businesspersons can make more money hawking tourist trinkets than top university graduate engineers could ever hope to make in their profession, at least in the present system. So how many will stick it out in the hope of being rewarded for the important long-term contributions they can make?

Still, there is incredible potential and the issue is how to help them harness their talent and resources for mutual benefit. We have some answers for them and the West does still control the game in many ways. However, we certainly don't have all the answers; we as a society have often demonstrated our short-sightedness and unwillingness to sacrifice now for future gain. However, I believe those who invest part of themselves in the Russia that I saw will benefit more than they give, especially if they're interested in more than simple economic return.

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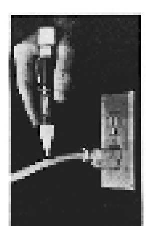

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