IEEE EMC SOCIETY

The Product Safety Newsletter

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What's Inside

Chairman's Message

Standards: Beauty or the Beast


Brian Claes

The semiconductor equipment industry is performing a major revision of its basic product safety standard, SEMI S2-93, Safety Guidelines for Semiconductor Manufacturing Equipment. The first order of business has been to decide on the basic nature of the revised standard. Should it remain largely principle- and performance-based or expanded to include a range of prescriptive requirements? The considerable majority of those participating in its revision adamantly affirm that it should remain a compact, high-level performance document. Curiously, however, as work proceeds the actual text that is being generated is growing like a cancer with more and more prescriptive requirements being added.

The frustration of watching an exemplary standard deteriorate into a collection of prescriptive requirements drove me to ponder the whole matter of how product safety standards are generated and revised. Remember UL 478, Safety of Electronic Data Processing Equipment? In 1980, the fourth edition of UL 478 was barely 50 pages of not very compact prescriptive requirements. Its current successor, UL 1950 (third edition) is now 260+ pages long, with a bright future of future expansion. What's been the benefit of this requirements explosion?

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The Product Safety Newsletter

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Central Committee

Chairman:	**Brian Claes**	**(510) 659-6574**	
		(510) 659-6852 (fax)	
Vice Chair:	**Richard Pescatore**	**(408) 447-6607**	**Pescatore@cup.hp.com**
Sec./Tres.:	**John McBain**	**(415) 919-8426**	**john_mcbain@hp.com**
		(415) 919-8504 (fax)	
Symposium:	**Mark Montrose**	**(408) 247-5715**	

Local Groups

	CHICAGO		
Chairman:	**John Allen**	**(708) 238-0188**	
	COLORADO		
	Richard Georgerian	**(303) 417-7537**	**richardg@exabyte.com**
	SO CAL/ORANGE COUNTY		
Chairman/Sec.:	**Charlie Bayhi**	**(714) 367-0919**	
	PACIFIC NORTHWEST (PORTLAND)		
Chairman/Sec-Tres.:	**Scott Varner**	**(503) 656-8841**	**4772949@mcimail.com**
	NORTHEAST PRODUCT SAFETY SOCIETY (NON-IEEE)		
	Arthur Michael	**(860) 344-1651**	**amichael@safetylink.com**
	SANTA CLARA VALLEY		
Chairman:	**Edward Karl**	**(408) 986-7184**	
	SEATTLE		
Chairman:	**Walt Hart**	**(206) 356-5177**	**walthart@tc.fluke.com**
	TEXAS (CENTRAL)		
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Newsletter Committee

Editor	**Roger Volgstadt**	**(408) 285-2553 (fax)**	**volgstadt_roger@tandem.com**
Subscriptions	**Dave McChesney**	**(408) 296-3256 (fax)**	
Institutional Listings	**Ron Baugh**	**(503) 691-7568 (fax)**	**ron.baugh@sentrol.com**
News & Notes	**John Rolleston**	**(614) 438-4355 (fax)**	**jhrolles@freenet.columbus.oh.us**
Activities Editor	**Kevin Ravo**	**(408) 296-3256 (fax)**	**ravok@ul.com**
Page Layout	**Eileen H. Mae**	**(408) 556-6044 (fax)**	**maee@ul.com**

Area Activities

by Kevin Ravo
Underwriters Laboratories Inc.
voice: (408) 985-2400 ext. 32311
fax: (408) 296-3256
e-mail: ravok@ul.com

The following is a brief overview of recent and planned activities for the various Local Groups around the USA. If you are aware of any 'activities' information that may be of interest to readers, please forward it to the above address and I will try to include the information in the next issue.

Central Texas Chapter

Jack Burns
voice: (512) 248-2851
Meetings are the last Wednesday of each month.

September Meeting: Mark Maynard, Dell - Regulatory Environmental Design
Jack Burns, Eaton - Professional Accreditation
October Meeting: Brian Claes, National President PSTC - PSTC Status with IEEE

Chicago Area

John Allen
voice: (708) 238-0188
Nothing to report this time.

Colorado Chapter

Richard Georgerian
voice: (303) 417-7537
fax: (303) 417-7829
e-mail: richard@exabyte.com

September Meeting: Ron Duffy, HP - Mitigating Safety Awareness

Northeast Product Safety Society

Mirko Matejic
voice: (508) 549-3185
web site: http://www.safetylink.com/npss.html

September Meeting: Isador Strauss, Curtis-Strauss - EC Power Line Harmonic Requirements
October Meeting: Dave McDaniel, BMS - Disaster Recovery Planning

Orange County, Southern CA

Charlie Bayhi
voice: (714) 367-0919

Coming in January 1997, the 'Test of the Month' show and tell at each meeting where practical safety topics will be discussed.
September Meeting: Planning Meeting
October Meeting: Henry Lurch, P.E., Power Eng. Assoc. - Electrical System Topology, The Problems with Grounding

Pacific Northwest Area

Scott Varner
voice: (360) 817-5500 ext. 55613
fax: (360) 817-7829
e-mail: 4777294@mcimail.com
Nothing to report this time.

Continued on next page

News and Notes

by John Rolleston

Internet Resource

Checkout the Internet for the International Product Safety News on the Web. The address is http//WWW.safetylink.com. Contained in this page are an excellent list of product safety resources, a list of safety articles you can read and print, and other excellent resources you can tap into.

Standards Engineering Society(SES)

The SES has sponsored and published a standard for guidance in how to write a standard. ANSI has added it to their index of standards. Titled “Recommended Practice for Standards Designation and Organization” it is available through ANSI as SES 1:1995. Or order from SES, 1706 Darst Ave., Dayton, Ohio. FAX 513-258-0018 or phone 513-258-1955. This recommended practice establishes uniform designations, titling, and formats for standards and promotes the use of keywords and abstracts in standards.

Revised Safety Signs, Colors, Standards and Symbols

Ansi has formed a Z535 Committee to examine the current safety sign standards Z535.1 through Z535.5. The intent is to bring the ANSI standards closer to the ISO standard #3864 on safety signs and labels. Work will include U.S. Technical Advisory Group(TAG) to the ISO, TC 145 Committee which will be responsible for conducting comprehension testing of signs, symbols and colors. The work will continue until early December, 1996. For further information contact Molly Bolger at (703)841-3227 or Ron Runkles at (703)841-3278.

House Passes Metric Bill

July 23 1996 H.R. 2779 bill was passed by the House of Representatives. Now the bill must go before the Senate. This bill is designed to provide an ombudsman who will be responsible for reviewing and responding to complaints from industry where enforcement of the Metrication places an undue hardship upon any segment of industry.

ANSI Explores International Occupational Health and Safety Management Systems(OHSMS)

At a May, 1996 OHSMS workshop many individual stakeholders spoke and heard comments about the need for OHSMS standards. Views varied from a majority saying “Do nothing” to a few supporting the action in support of global safety and health environment as well as supporting movement towards global economy. Findings of this workshop and summaries of the views presented are to be presented at a September 1996 Issue of the ANSI “Reporter”. More information is available through ANSI at (212)642-4900.

Safer Automobiles

NIST has joined forces with General Motors to study the unsafe crash and fire characteristics of automobiles and what passive protection measures might be taken to reduce injury and death from such accidents. For example, the use of fire retardant materials. For more information contact John Blair at (301)975-4261.

OMB A-119 Becomes Law

This “Voluntary Standard System Law” has had an active life in the annals of standards makers. First created in 1982 and revised in 1993 this law gained the force of law behind it with President Clinton's signature, March 7, 1996. Provision (12(d)) requires that all Federal agencies and departments use the work of voluntary consensus standards setting bodies. Technical standards must now be used unless it is shown that such is "inconsistent with applicable law or otherwise impractical." ■

By Dave Edmunds

Laser Safety Conference

A 1997 International Laser Safety Conference is planned for March 17-20, 1997 in Orlando FL. This conference is sponsored by the LIA (Laser Institute of America).

Topical areas are :

- New and Developing Safety Standards
- Enforcement of Safety requirement
- Research in vision & Bioeffects
- Laser and LED Safety in communication systems
- Protective System Devices
- Laser hazard and Analysis
- Laser Safety in Entertainment/Airspace

Special Panel Discussion - Regulator Compliance & Reform Issues

For further information LIA, 1242 Research Parkway Suite 125, Orlando FL 32826 FAX: 407 380-5588 ■

Area Activities
Continued from Page 3

Santa Clara Valley

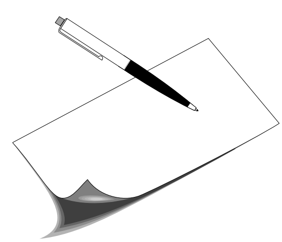
Edward Karl
voice: (408) 986-7184

Meetings are on the fourth Tuesday of each month.
September Meeting: Planning meeting for the 1996 - 1997 year.
October Meeting: Low Voltage Directive
November Meeting: Laser Safety
December Meeting: Combined meeting with EMC Society

That is it for now. Please remember to forward any information that may be of interest for next time.

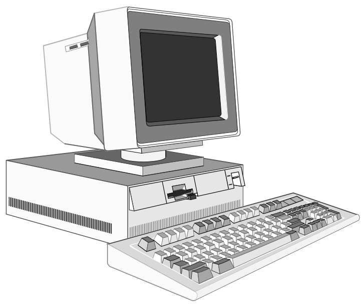
Live Long and Prosper,
Kevin L. Ravo ■

We are looking for Product Safety Articles!



Please send your articles to:
Roger Volgstadt
Tandem Computers
M/S 55-53
10300 N. Tantau Ave.
Cupertino, CA 95014

Safety Net — News from the Internet



By John Quinlan

This issue's topic: sources for regulatory standards other than the original issuing regulatory agencies. A dialog was initiated on the TREG forum by Jack R. Marshall <marshall@world.std.com> on 8/18/96. His post elicited responses from Stephen C. Phillips <stephen@cisco.com>, Ron Pickard <ronp@syntellect.com>, Mike Miele <m_miele@smtpgate.chelmsford.telebit.com>, Tania Grant <tania.grant@octel.com>, Dana Craig <dcraig@dl.com> and Mirko Matejic <mmatejic@foxboro.com>.

The following list has been compiled from those responses. My apologies to any sources which may have been inadvertently left out — please email me with any additions and/or corrections and I will see that they get published in a subsequent column.

SOURCES FOR REGULATORY STANDARDS

American National Standards Institute
11 West 42nd Street, New York, NY 10036 USA
URL: http://www.ansi.org/cat_b.html
Voice: (212) 642-4900, Fax: (212) 302-1286
(non-profit clearinghouse for IEC, IEEE, ISO and other standards)

British-American Chamber of Commerce
Suite 303, San Francisco, CA 94104 USA
Voice: (415) 296-8645, Fax: (415) 296-9649
(source for IEC, BS, EN, ISO, DIN, ETSI and other European standards)

Compliance Engineering Standards
One Tech Drive, Andover, MA 01810 USA
Voice: (508) 681-6673, Fax: (508) 681-6637

Custom Standards Services
802 Oakland Avenue, Suite 5, Ann Arbor MI 48104 USA
email: service@cssinfo.com
URL: http://www.cssinfo.com/index.html
Voice: (800) 699-9277, Fax: (313) 930-9088

Document Center Inc.
1504 Industrial Way Unit 9, Belmont, CA 94002 USA
email: info@doccenter.com
URL: http://www.doccenter.com/doccenter/
Voice: (415) 591-7600, Fax: (415) 591-7617

EuroPort
PO Box 243, Manchester, MA 01944 USA
email: EuroPort@shore.net
URL: http://www1.shore.net/~eurocnslt/europort
Voice: (508) 526-1687, Fax: (508) 526-7118
(source for international standards, VDE Publications: source of EN, VDE, ISO, DIN, BSI and other standards)

European Document Research
1100 17th Street, N.W., Suite 301, Washington, D.C. 20036 USA
email: edrwash@mail.erols.com
URL: http://world.std.com/~billsmr/edr.html
Voice: (202) 785-8594, Fax: (202) 785-8589

Global Engineering Documents
7730 Carondelet Avenue, Suite 407, St. Louis, MO 63105 USA
Voice: (800) 854-7179

Horrocks Technology
Bethany, Chapel Lane, Pirbright, Surrey GU24 0JZ UK
email: 100441.727@compuserve.com
URL: http://ourworld.compuserve.com/homepages/Horrocks_Technology

Voice: +44 1483 797807, Fax: +44 1483 797617
(EC documents available on floppy disk or CD ROM, with all updates worked in)

Standards Sales Group
15885 Main Street, Suite 250, Hesperia, CA 92345-3403 USA
Voice: (619) 947-6100, Fax: (619) 947-2899

U.S. Department of Commerce, International Trade Administration
Office of European Union and Regional Affairs, Washington, DC USA
Voice: (202) 482-5279, Fax: (202) 482-2511
(source of directives, guides and lists of standards for various fields)

Her Majesties Stationery Office
(HMSO), 51, Nine Elms Lane, London, SW8 5DR, UK
Voice: +44 171 873 8409, Fax: +44 171 873 8463
(source of directives and guides) ■

Technically Speaking

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THE DIELECTRIC WITHSTAND (HI-POT) TEST

There always seem to be questions about hi-pot testing. Maybe I can present some of those questions and their answers.

SOME DEFINITIONS.

What is “hi-pot”? This is an acronym for high-potential.

What is “dielectric withstand”? This is a short-hand phrase for dielectric withstand (or withstanding) voltage. It is a voltage which a dielectric material (insulator) will withstand without breaking down.

What is “electric strength”? This is nearly the same as dielectric withstand. It is the highest voltage at which the specific insulation will not break down.

What is “breakdown”? This is the failure of an insulator due to the voltage impressed across it.

WHAT IS THE HI-POT TEST?

The hi-pot test applies a relatively high voltage between the primary circuits and the protective grounding conductor. For two-wire products, the high voltage is applied between the primary circuits and accessible conductive parts (or foil wrapped around accessible non-conductive parts).

WHAT IS THE SAFETY PURPOSE OF THIS TEST?

To answer this question, we need to (1) identify what part fails when the product fails the test and (2) identify the safety consequences of that part failure.

Since we are applying a voltage between the primary circuits and the grounding circuit (or accessible conductive parts), the part we are testing is insulation. The insulation between any point of the primary circuit and the grounding circuit is either solid or air, or both solid and air in series.

In the event of a hi-pot failure, there is a failure of either the solid insulation or the air insulation.

If the failure is solid insulation, then a conducting path is impressed upon the surface or through the solid insulation, and the insulation is destroyed catastrophically. The material is no longer an insulation, but is now a resistor of indeterminant value. The resistance may be sufficiently low value to allow an electric shock to occur from grounded parts (in the absence of ground) or from accessible conductive parts.

If the failure is air insulation, then a conducting path exists for the duration of the test. When the high voltage is turned off, the system returns to normal because air is a renewable insulation. A shock could exist for the duration of a primary-circuit overvoltage.

(Interestingly, safety standards authorities and certification house authorities commonly do not permit breakdown of air insulation even though, in practice, the breakdown only exists for the duration of the overvoltage. Following the arc event, the air in the clearance is renewed and the construction is returned to its pre-breakdown state.)

The purpose of the dielectric withstand (hi-pot) test is to determine whether the insulation from the primary circuit to grounded or accessible parts has sufficient electric strength to withstand the normal overvoltages which could occur in service.

WHY IS THE TEST VOLTAGE SO HIGH, I.E., MORE THAN 10 TIMES THE RATED INPUT VOLTAGE?

Electric current in an inductor creates a magnetic field. When the current is switched off, the magnetic field collapses, generating a current in the opposite direction. This current can generate a very high voltage impulse into the power distribution system. Such impulses are entirely normal (e.g., during the starting process of an electric motor).

Because high-voltage impulses are impressed upon the power line, all insulations on a power distribution system (including product internal insulations) must have sufficient electric strength to withstand not only the normal system operating voltage, but also the normal system overvoltages, i.e., the high voltage impulses. Consequently, product primary-to-ground insulations must be tested with a high voltage to confirm that the insulations will not break down under normal conditions. Note that normal conditions include high-voltage impulses.

Many studies of power line overvoltages have been published. As a general rule, overvoltages on 120-volt systems are less than 1000 volts peak. Overvoltages on 230-volt systems are less than 1500 volts peak.

HOW DOES VOLTAGE CAUSE INSULATION TO FAIL?

Air is the culprit behind virtually all insulation failures.

Air is either an insulator or a conductor, depending on the voltage impressed across a specific distance. In very round numbers, and for the sake of discussion, we will assume that air can withstand about 1000 volts per millimeter. At voltages above 1000 volts per millimeter, air will break down, and an arc will occur.

Likewise solid materials are either insulators or a conductors, depending on the voltage impressed across their thickness. For the sake of discussion, we will assume that solid insulation can withstand about 10,000 volts per millimeter. However, the breakdown of solid insulation usually involves the breakdown of air.

Consider a solid insulation 1 millimeter thick with 10,000 volts impressed across it. If air was trapped in the solid insulation, then it is possible that the air would be subject to more than 1000 volts per millimeter. If this occurs then the air within the solid insulation will break down and an arc will occur. The temperature of the arc could cause a carbon path in the void where the air was trapped. This effectively shorts out a small part of the insulation, thus increasing the volts per millimeter of the remaining insulation. This could cascade to other sites where air is trapped, and a catastrophic insulation failure occurs.

A good solid insulator is characterized by having virtually no air trapped within the solid material.

Air entrapment within a solid material is not the only solid insulation failure mechanism. If we provide several layers of thin insulation such as in a transformer or a capacitor, air will be trapped between the layers. The same failure sequence can occur.

HOW DO YOU DETERMINE IF A FAILURE HAS OCCURED?

A hi-pot failure occurs when there is an arc in a clearance, or an arc which damages solid insulation.

Various third-party safety certification houses have made many pronouncements as to what constitutes a hi-pot failure. There are two popular ones: (1) the voltmeter does not increase linearly as the voltage is increased, and (2) the ammeter increases non-linearly as the voltage is increased.

These are both reasonable indicators that the insulator is not behaving properly. Such meter behavior can be due to the air within an insulation system breaking down in small pockets, but not yet resulting in a complete breakdown of the system.

We should not rely on the meter readings as always representing an insulation breakdown. Always find the point of arcing and the point of breakdown. This may mean disassembling the product or component, and repeating the test on the remaining assembly and on the individual parts.

If the hi-pot tester is the collapsing field type, and the unit under test requires a high test current, the tester can indicate a non-linear change in voltage or current yet the unit under test may not have incurred a breakdown.

The best way to tell if a failure has occured is to look for the arc, or for evidence of arcing. Look and listen for the ZAP!

If part of the insulation breaks down due to failure of a small number of air pockets, does this constitute a breakdown? Clearly some of the insulation has been damaged. However, if the insulation still passes the hi-pot test, then the system is okay. (This scenario can occur!)

WHICH IS BETTER, AC OR DC?

Some say because ac more readily ionizes air than dc, ac is a more sensitive test. Some say because ac more readily ionizes air than dc, dc is a less stressful test.

At the common test voltages used for electronic products, in the range of 1000 volts to 3500 volts rms or so, there is no conclusive evidence that either is the better test.

AT WHAT CURRENT SHOULD I SET THE HI-POT TRIP POINT?

It doesn't matter.

In the "old days," hi-pot testers had no current trip. The only way you could tell a failure (other than hearing the ZAP!) was that the voltmeter would fail to advance to full voltage. Some hi-pot testers also had ammeters, in which case you knew you had a failure when the ammeter needle pinned to the high end of the scale.

Having said that, there is a minimum value of current that the test requires to avoid nuisance tripping.

The minimum value of hi-pot test current is proportional to measured leakage current.

If you are doing an ac hi-pot test, then the hi-pot current will be proportional to the ac leakage current. If you are doing a dc hi-pot test, then the hi-pot current will be proportional to the dc leakage current.

Specifically:

$$\text{hi-pot current} = \frac{\text{hi-pot test voltage}}{\text{leakage I test voltage}} \times \text{leakage current}$$

You can also calculate the hi-pot current from the capacitive reactance of all the Y-capacitors in the primary circuit. You will need to add some capacitance to account for the primary-to-ground capacitance of the mains circuits and transformer.

The hi-pot trip current must be set at some value greater than the actual current required for the hi-pot test. The value must account for the component and manufacturing tolerances contributing to leakage current (the tolerances of the Y capacitors and the variation in primary-to-ground wiring capacitances).

For example, if the 250-volt leakage current is 2.0 milliamperes, then the hi-pot current for a 1500-volt hi-pot test would be:

$$\text{hi-pot current} = \frac{1500}{250} \times 2.0$$

$$\text{hi-pot current} = 12.0 \text{ milliamperes}$$

You would set your hi-pot trip current at, say, 15 milliamperes to account for component and manufacturing tolerances.

Some people set the trip current at a value to find wrong-value EMC filter capacitors. I don't believe it is very useful to use the hi-pot test to discriminate against excessive primary-to-ground capacitance.

Having said all this, I now say that the actual value of the trip current is not important.

In manufacturing, the purpose of the hi-pot test is to to find gross manufacturing errors (which are catastrophic hi-pot failures). Gross manufacturing errors are indeed gross, and usually show up at much lower voltages and much higher currents than those required for the test.

Except for BABT, the various safety certification houses do not specify hi-pot trip current limits.

WHAT ARE THE CERTIFICATION HOUSE REQUIREMENTS FOR HI-POT TESTERS?

Some certification houses require the hi-pot tester to include a manual reset following a hi-pot failure. Some certification houses require visual, audible, or both indications of a failure.

These requirements negate automated hi-pot testing on an otherwise automated production line.

WHAT IS THE EFFECT OF HUMIDITY?

In some cases, a required hi-pot test follows humidity treatement. The purpose of this sequence is to find hygroscopic (water absorbant) insulating materials.

Supposedly, the humidity treatment does not include dew-point conditions. If this is the case, then the air trapped within the insulating materials can be assumed to have relatively high humidity as a result of the humidity treatment. The assumption is that humid air has less dielectric strength than dry air.

This is a false assumption. Humid air actually has equal or greater electric strength than dry air! Water vapor is a gas, and does not have the same properties as water in the liquid state. ■

Determining the Acceptability of Safety Risks

Paul W. Hill

[We are grateful to the author for providing a series of condensed installments from his book "Managing Product Safety Activities." This text is a registered copyright of Paul W. Hill & Associates, and is reproduced with permission. Details about the book may be obtained by calling (704) 892-6982. -ed.]

It is not likely that a product can be designed and put into production which does not contain some element of risk of electric shock, becoming a source of ignition, utilizing a toxic material or capable of causing personal injury.

Mains operated products will require electrical energy within the product at levels clearly capable of inducing electrical shock and ignitions. The dimensions and mechanical aspects of the product present opportunities for physical instability, sharp points, and injury from moving parts. In addition, use of a product not intended by the designers and product developers, with the additional safety uncertainties this implies, is always present and generally beyond the control of product developers once the product enters commerce. Compliance with industry safety standards and safety certification of a product is a positive and necessary step but readily acknowledged to be insufficient in itself for reasons discussed in the section "Designing Beyond Requirements of Standards."

For these reasons the best of products will always contain some level of safeness uncertainty called risk. Some safeness risks are acceptable and other unacceptable. Decisions will be required to remove the risk, reduce a risk to acceptable levels or accept the risk as it is.

> Clearly, managers need some risk evaluation process such that responsible and readily defendable positions are taken on safeness risk issues.

The following discussion illustrates approaches to product safety risks and outlines criteria for judging the acceptability of safeness related risks.

Approaches to safety related risk acceptance.

There are several approaches to determining an acceptable level of risk. Some use a purely statistical approach which yields a numerical probability of a safety incident occurring. Others approach risk as a matter of economics concerned with the costs of repair, replacement or warranty charges against the product. Still others may consider the likelihood and estimated cost of litigation actions and determine the appropriate amount of insurance to provide for potential losses due to safety issues.

While each of the these approaches may have some merit and some application to the problem, the standard of acceptance of risks used here will be the **test of reasonableness**.

On first reading the word "reasonableness" one may have the impression that the word is very subjective. However, the term can become quite objective and discerning in product safety work when certain criteria for reasonableness are applied.

The criteria or test of reasonableness discussed in this section will be taken from those covered in the work of the National Commission on Product Safety and the criteria used by the Consumer Product Safety Commission in determining if a product contains a hazard which constitutes an unacceptable level of safeness. The risk assessment factors which determine the reasonableness of a product safeness risk are:

1. Awareness of product users that a hazard exists.

2. Likelihood the hazard will be encountered.

3. Ability of the user to cope with the hazard should it be encountered.

4. Approach used by others with similar product hazards to remove or reduce the risk.

5. Cost or performance impact to the product if the hazard is to be eliminated or substantially reduced.

6. Necessity of accepting the risk because there appears to be, after due consideration, no other alternatives.

The following sections examine this concept of safety risk assessment. The intent is to provide a process which leads to a decision to either eliminate the risk by corrective actions, reduce the risk to acceptable levels or accept the risk and potential consequences.

Applying the test of reasonableness.

Risk as used in product safety can be illustrated by examples to which every interstate highway user can relate and perhaps has actually encountered.

Situation 1.

Visualize a large deep pot hole in the surface of a heavily traveled interstate highway. The pot hole is large enough and deep enough to cause serious damage to a vehicle at normal highway speeds. In addition, striking the pot hole may cause a vehicle to careen out of control and endanger other vehicles on the roadway. Traffic in other lanes are also in danger of collision as vehicles maneuver unpredictably at highway speeds to avoid the pot hole.

Clearly, the pot hole is a hazard to all using the roadway. The risk tolerance of this hazard until repairs can be completed can be determined by applying the tests of reasonableness given above.

1. Degree of awareness. The presence of an unmarked obstruction will not be obvious to all drivers. Many will unintentionally encounter it in heavy traffic, in foul weather and at night.

2. Likelihood of encounter. It is clear that almost all vehicles on the roadway are in danger of an injury or property damage,

either from contact with the pot hole or with vehicles careening out of control or unpredictably maneuvering in traffic to avoid it.

3. Ability to cope. The driving skills necessary to safely maneuver around unmarked obstructions at highway speeds is not within the ability of the general public using the roadway. These skills are not required to obtain a driver's license nor are these skills naturally occurring in the driving public.

4. Approach used by others. There are techniques in common practice for avoiding highway obstructions such as construction areas and maintenance work. These are in the form of warning signs, posted instructions, lane merging around obstructions and barriers which isolate traffic from roadway obstructions.

5. Cost to eliminate. The cost to repair the pot hole is very small compared to the costs associated with personal injuries, property damage and litigation actions of not repairing the obstruction or delays in isolating it from roadway traffic.

6. Necessity to accept the risk. There are alternatives to acceptance of the pot hole as the inevitable lot of highway users. It is common practice to detour road traffic around obstructions, place warning signs and isolate obstructions by the use of guards or barriers. It is not necessary to close the road to traffic or require lengthily detours to avoid a pot hole.

The presence of an unmarked pot hole would be an unacceptable risk based on the tests of reasonableness. In terms of risk management the situation must be made acceptable by some means of isolating the pot hole from all traffic until repairs can be completed.

Situation 2.

Consider the same highway pot hole under these conditions. Two miles from the pot hole a conspicuous sign warns drivers of a roadway obstruction ahead. One mile from the pot hole a sign warns of reduced speed ahead. One half-mile further on a sign with flashing yellow lights directs drivers to merge into one lane. Fifty yards from the pot hole a barrier separates the usable lane from the lane with the pot hole. Beyond the pot hole a sign advises motorists to resume normal road speed in all lanes.

When applying the six criteria of risk acceptability to the second pot hole situation one finds the obstruction to be acceptable until permanent repairs can be completed. Motorists are warned of the hazard and provided with instructions permitting them to cope with the situation in a manner within the comprehension and capability of licensed drivers. The use of warning signs, reduced speed areas and barriers around roadway obstructions is common practice for highway repair or construction work. It is not necessary to research or develop new methods of traffic control in the area of roadway obstructions.

The cost of repair is small compared to the potential costs of allowing the pot hole to remain unmarked or not isolated from highway traffic. The minor inconvenience of slowing speed for one mile and merging lanes is much more acceptable than disruption of traffic flow by highway closure or an off-road detour.

This illustration of the pot hole under two sets of conditions is strikingly similar to the nature of risks encountered in product safety activities.

Risk reduction in product safety.

Of the many possible safety exposures these items may cause, three examples will be illustrated which address restricting access to hazards, inadequacy of warnings and misconceptions about electric shock hazard levels.

***Accessibility of hazards*.**

Nearly every product safety standard recognizes the IEC probe in the rigid or articulated configuration as the measurement for access to hazards such as moving parts, contact with conductors carrying hazardous voltages or high currents and the operating responsiveness of interlock devices. The origin of the shape and dimensions of the IEC probe are obscure but are believed to represent a hand digit of an adult male. For many types of equipment the adult male finger may be representative of the expected user population. However, it is totally inappropriate as a measure of accessibility to hazards if products are accessible to the general public which includes women, young adults and children.

In the real world it is clear that children, young adults and women are frequent users of telephones, personal computers, hand tools, hair driers, photocopiers, light industrial tools found in homes and schools, plus many more types of equipment which come into direct contact with this user population. All of these items involve moving parts, hazardous voltages or other hazards which must not be accessible to the user. Yet the criteria for the determination of accessibility of hazards in industry safety standards for this equipment is the adult male oriented IEC test finger.

Clearly, the IEC probe does not reasonably represent the accessibility of the general user population of many electrical, electronic and electro-mechanical devices. Its dimensions and general shape make it unrepresentative of women, young adults and children.

The probe illustrated in Figure 9.3.2 results from a survey by a product testing facility of the ability of the general population of men, women and children to touch conductive surfaces through openings of varying size and depth.

It can be seen that the two probes will provide different levels of accessibility if used to determine the distance a finger can intrude into an opening in equipment containing mechanical or electrical hazards. To appreciate the significance of the difference in extent of accessibility permitted by the probes a comparison of penetration depth was conducted with the results shown in Appendix D.

The UL Live Parts Probe for measuring accessibility to interiors of equipment would be more realistic for products likely to come in with the general public. On the surface this would appear to be an over-design situation since the UL probe is not a product safety certification or listing requirement. However, the basis for its configuration and dimensions are well founded and will provide a degree of inherent safeness not provided by the IEC probe.

The use of the IEC probe as a criteria for accessibility clearly poses a risk to a segment of the population which may come in contact with the product. From the risk management point of view this risk would be unacceptable. Consider the following factors:

1. If the product displays the logo or monogram of a testing agency the equipment would be presumed to be safe and not arouse the awareness of some users that contact with a potential hazard is possible.

2. The cost or performance impact would not appear to be prohibitive to initially de signed enclosure openings to the smaller width while maintaining the same total area of openness for ventilation or other purpose of the enclosure opening.

3. Others have used the UL probe (i.e., telephone equipment) and the basis for the dimensions and shape of the probe are technically sound.

4. There is no compelling reason to accept the IEC probe as the only criteria for establishing the permissible access to openings in enclosures in view of the existence of the UL probe.

Risk management in such cases would permit the product to be safety certified or listed to the IEC probe requirements, but have been designed to the more realistic and more appropriate UL Live Parts Probe or one of similar configuration and general dimensions.

In this example the risk is reduced to more acceptable levels by utilizing an access criteria known to be more sensitive to women, young adults and children.

Inadequacy of warnings.

A survey of residences in the United States suggested that perhaps as many as one quarter of the receptacles do not provide an acceptable electrical earth ground. The causes are well understood. Many residences were constructed before polarized or three wire outlets were electrical code requirements. Many result from miswired outlets with the black, white and green wires are interchanged. Some result from improper re-installation following remodelling or failure to actually connect the green wire to an earth ground circuit. Some installations are visually checked only and not electrically tested for a functional low impedance earth ground.

Connecting equipment with Class I insulation systems to inadequately earth grounded outlets poses a serious electrical safety risk. Aware of this safety exposure, some manufacturers place warnings in installation and operating instructions which advise the user to connect the equipment only to outlets which are properly earth grounded. Some warnings go further and suggest that if in doubt of the receptacle grounding one should consult a qualified electrician.

It is clearly foreseeable that the cost of an electrician service call, delays in becoming operational and the inconvenience of heeding the warning will cause many to assume the receptacle is usable. Many will reason that other appliances have used the receptacle without problems and assume it to be electrically satisfactory.

This situation represents an unacceptable safety risk because:

1. Warnings are passive measures and are never acceptable when the hazard can be significantly reduced or avoided by design.

2. It is foreseeable that the general public will not be in a position to judge by a meaningful electrical test if the services of a qualified electrician are required.

3. Others have found an effective solution to the problem without involving significant cost or performance penalties.

The equipment is unsafe to operate because a basic premise of electrical safety is violated, namely, a second level of protection is not being provided should the basic insulation be faulted. For Class I equipment the second level of protection is the earth ground.

One possible solution is to provide a Class II insolation system in which the second level of protection from electric shock is the supplemental insulation of the device. However, for various reasons it may be desirable to preserve the Class I insulation system and its performance characteristics in the equipment.

A reasonable solution is to design the isolation transformer, the interface of mains and secondary circuits, to Class II dielectric strength and spacing requirements while maintaining the earth ground wire. The result is an insulation system that is Class I in electrical characteristics but behaves as if it were a Class II transformer in its dielectric strength and electrical safety features.

The size of the transformer and its prime cost are not significant if designed from the start with these electrical characteristics. The principle reason for this is the very high dielectric strength of insulating tapes used in transformers. The thickness of the tape and overlap spacing distances which moves the dielectric strength from Class I to Class II levels is very small. The transformer still retains its earthing ground wire for Class I performance characteristics but has gained the second level of protection from electric shock as if it had re-enforced or supplemental insulation.

As a result of this design approach the safeness risk due to the lack of a functional earth ground in the outlet is avoided or greatly reduced. The equipment becomes essentially insensitive to the presence or lack of a functional safety earth ground in receptacles relative to electric shock hazards associated with the lack of a functional earth ground.

> In this risk situation the passiveness of warnings and foreseeable noncompliance with user installation instructions is replaced by a positive design action.

All six of the criteria for reasonableness are satisfied by this one design consideration.

Electric shock levels.

Not all product safety standards use the same voltage or current values as being safe to touch. In most product safety standards a voltage level of 42.5 peak or 60 volts DC is considered the demarcation between safe and hazardous voltages. Several newer standards permit much higher voltages as safe to touch circuits.

Recent work in an IEC technical committee suggests that for women and children a given

level of electric shock is considerably more severe than for adult men. Most values in standards are based on adult male shock responses. The IEC work indicates that a woman's electric shock tolerance is 70% and a child 50% that of an adult male. This difference is primarily due to a factor in
electric shock considerations which relates to body mass. For equipment which may be exposed to women and children the permitted voltages on accessible conductive parts, both under normal and fault conditions, should be much lower than those levels permitted by nearly all product safety standards.

To reduce the risk of electric shock in equipment accessed by women, young adults and children the permitted touch voltages should be only 70% to 50% of the levels allowed in most safety standards.

In this situation the risk of a severe reaction to electric shock is reduced by designing to requirements more appropriate to the likely user population rather than the more general shock levels permitted by many industry product safety standards.

The final requirement of risk acceptability.

Risks are taken, knowingly or unknowingly, at all stages of product development due to design tradeoffs, component and materials modifications, parts supplier change decisions and many other isolated judgments as the product evolves. Taken one at a time each risk may be small and reasonable to those making the isolated risk acceptance decisions. At some point all risks assumed during product development must be considered collectively.

Some safeness aspects will become apparent in fault testing, others during prototype modelling and testing, still others during safety certification. Those safeness deficiencies which remain when the product development and testing has been completed are known as residual risks. These risks are resolved by one of two methods:

1. The deficiencies are corrected by redesign, component and material changes or other modifications to the product, its performance envelope or other measures which reduce the risks to acceptable levels.

2. The residual risks are accepted.

Both of these approaches have extensive financial, product marketing or liability consequences. Decisions of this magnitude are beyond product safety management responsibilities. These are the types of business decisions reserved for senior management as described in Section 4.6, Product Safeness Reviews.

> The key role for product safety management in risk decisions involving product safeness is the timely application of the test of reasonableness to each risk situation, documenting the conclusions and providing these data to those assigned to make risk acceptance decisions for the business. ■

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Ron Baugh at 503-691-7369 (phone) or 503-691-7568 (fax).

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c/o Tandem Computers Incorporated
10300 North Tantau Avenue, Loc 55-53
Cupertino, CA 95014
Attn: Roger Volgstadt

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