The Product Safety Engineering Newsletter

Vol. 3, No. 4 December 2007

What's Inside

President's Message

Henry Benitez

Hello Product Safety Engineering Society Members,

It has been a remarkable experience for me to serve as president of the Product Safety Engineering Society for the past 2 years. I have enjoyed being part of the growth of this Society. I have enjoyed working with the many wonderful PSES volunteers and watching their personal growth as leaders of this great organization. Mr. Jim Bacher will be the new PSES President starting in 2008. Jim has been actively involved with the PSES and former PSTC for many years. Jim will be an excellent leader to take this organization to the next level as we push our membership to greater than 1000, develop a PSES journal or magazine, develop more technical committees and make more significant progress with PSES conferences and workshops.

I enjoyed seeing so many of you at the PSES Product Compliance Symposium held this past October in Longmont, Colorado. The feedback has been very positive! I would like to thank August (Gus) Schaefer, UL Vice President, for his exciting keynote address. Exhibits increased over 100% this year and I expect to see similar increases in years to come as vendors become aware of the PSES event.

2008 will be the 5th anniversary for the Product Safety Engineering Society. The 5th annual PSES Symposium will be held in Austin, Texas. Austin has an active PSES Chapter and some enthusiastic volunteers to help organize the symposium. I look forward to this event as I expect that it will be spectacular.

Continued on Page 3

The
Product
Safety
Engineering
Newsletter

Newsletter Committee

Editor:			
Gary Weidner	1-563-557-0717 (v)	1-563.557.0725 (fax)	gweidner@ieee.org
Co-Editors:			
Michael S. Morse Ph. D.			mmorse@sandiego.edu
Richard Nute			richn@ieee.org
Nosh Medora			
Lal Bahra			
Lingfeng Chen			
Eric Sklar			
Lauren Crane			
News & Notes:			
			Your name here
Chapter Acitivities:			
Stefan Mozar	+86 139 2373 9161 (China Mobile)	+852 9128 7947 (HK Mobile)	s.mozar@ieee.org
Page Layout:			
Jim Bacher	1-937.865-2020(v)	1-937.865.2048 (fax)	j.bacher@ieee.org

IEEE PSES Officers

Executive Committee	Name	Term
President	Henry Benitez	(06-07)
Past President	Mark Montrose	(06-07)
President Elect	Jim Bacher	(07)
Secretary	Daniece Carpenter	(07-08)
Treasurer	Murlin Marks	(07-08)
Vice President - Communications	Dan Roman	(07-08)
Vice President - Member Services	Ken Thomas	(07-08)
Vice President - Technical Activities	Jack Burns	(07-08)
Vice President - Conferences	Richard Georgerian	(07-08)

Directors At Large

Term Expires 12/07	Term Expires 12/08	Term Expires 12/09	Ex Officio (without vote)
Jim Bacher	Jack Burns	Daniece Carpenter	Chapter Chairs
	Murlin Marks	Daniel Nachtigall	Standing Committee Chairs
Bansi Patel	Richard Pescatore	Richard Georgerian	IEEE HQ
Dan Roman	Ken Thomas	Elya Joffe	IEEE TAB Division VI Director

IEEE PSES Web Sites

http://www.ieee-pses.org/
http://www.ieee-pses.org/symposium/
http://www.ieeecommunities.org/emc-pstc
http://www.ieee-pses.org/emc-pstc.html
http://www.ieee-pses.org/newsletters.html
http://www.ieee-pses.org/pses.html

I welcome Doug Nix and Peter Tarver as new members to the PSES Board of Directors. Their enthusiasm and new ideas will be a welcome addition as the PSES moves forward. Jim Bacher and Mark Montrose were also elected to another term on the Board. I would like to thank all Board members and PSES volunteers for their support in making my job easy for the past two years!

Sincerely,

Henry W. Benitez

Henry Benitez

IEEE Product Safety Engineering Society
h.benitez@ieee.org

Tip: ***Best way to get your boss to approve your trip to the 2008 Symposium on Compliance Engineering is to submit a paper that gets accepted for the symposium! Or volunteer and tell him you have to be there!***

Chapter Safety Probes

Central Texas Chapter

Chairman : Daniece Carpenter
daniece_carpenter@dell.com

Santa Clara Chapter

Chairman : Steve Baldwin
steve.baldwin@lamrc.com
or
baldwinsg1@gmail.com

Oregon Chapter

Chairman : Dean Jurgensen
dean_jurgensen@logitech.com

Chicago Chapter

Chairman : Ken Thomas
kthomas@globalsafetysolutions.net

Rochester NY Chapter

Chairman : James Shipkowski
james.shipkowski@kodak.com

Boston Chapter

Chairman : John Freudenberg
jmfreudenberg@excite.com

Orange County Chapter

www.ieee.org/oc-pses
Chairman Paul Herrick
jpherrick@yahoo.com

IEEE PSES International Chapters

Taipei Taiwan Chapter

Chairman : Zenon Wang
Zenon_Wang@DELL.com

Israel Chapter

Chairman : Moshe Henig
moshe_h@itl.co.il

Vancouver Chapter

Chairman: Steven McClain
StevenM@AnalyticSystems.com

People Looking To Start Chapters

Denver Colorodo

Richard Georgerian
voice: (303) 833-2327
e-mail: richardg@ieee.org

Toronto Ontario

Doug Nix
dnix@ieee.org
voice: (519) 729-5704
FaX: (519) 653-1318

North Carolina

Warren Fields (ncps@bellsouth.net).

Dallas Texas

Mike Cantwell, PE
Sr. Account Representative
Intertek ETL SEMKO
420 N. Dorothy Dr.
Richardson, TX 75081
Tel: 972-238-5591 x107
Fax: 972-238-1860
e-mail: mike.cantwell@intertek.com
or
Bill Paschetag b.paschetag@verizon.net

Southern California

Charles Bayhi (bayhi@cpsm-corp.com).

Technically Speaking

by Richard Nute
Product Safety Consultant
San Diego
September, 2007

ELECTRIC SHOCK AND ELECTRIC SHOCK SAFEGUARDS
IN
DIGITAL CAMERA FLASH CIRCUITS

Introduction.

A few days ago, a CTL Provisional Decision Sheet was brought to my attention. The CTL is the “Committee of Testing Laboratories,” a part of the IECEE. CTL Decision Sheets and Provisional Decision Sheets document the answers (“decisions”) to standards interpretation questions raised by CTL members. (1)

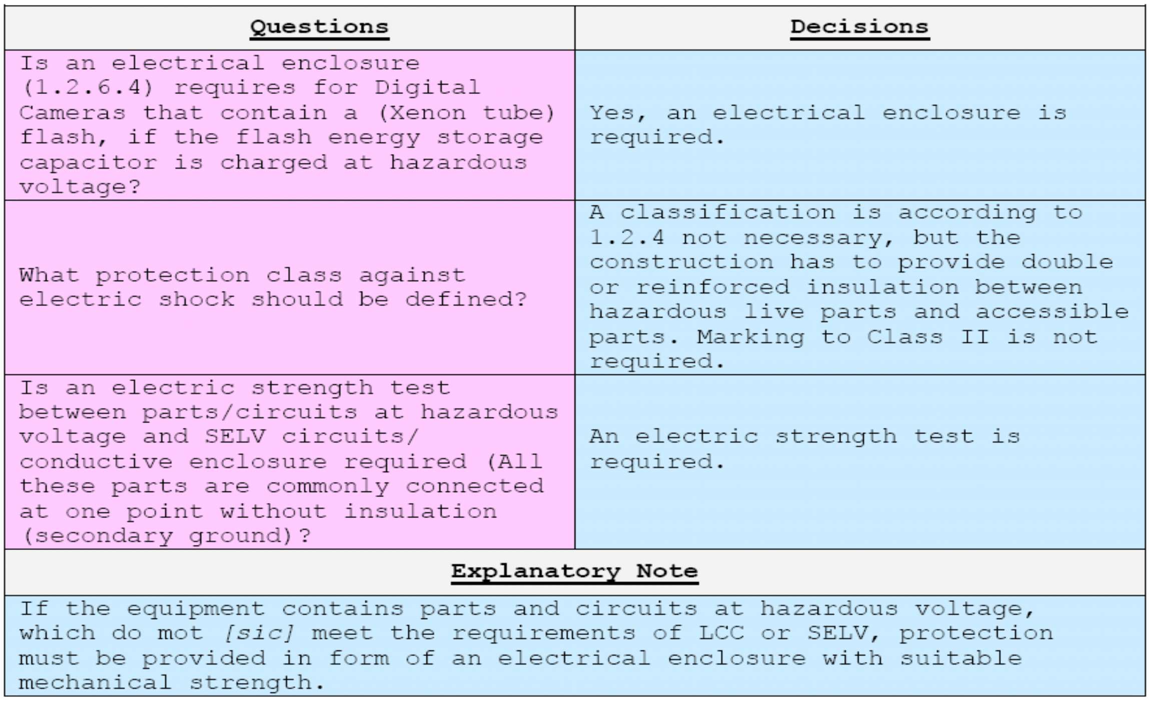
This particular Provisional Decision Sheet is in response to three questions about flash circuits in digital cameras. Flash tubes operate on high voltage. So, we have a battery-operated device with internal high voltage assumed to be capable of rendering an electric shock.

We’ll look at the questions, examine the schematic, determine what parts could render an electric shock, and then identify the necessary safeguards and the safeguard requirements.

This discussion is for a consumer-grade camera with integral flash. While the principles of circuit operation apply to most flash circuits, the safety principles apply to small, low-power consumer-grade equipment.

Provisional Decision Sheet questions.

Here are the questions, answers, and explanatory note as published by the CTL in the Provisional Data Sheet. The standard in question is IEC 60950-1, and the questions are in regard to sub-clauses 1.2.4.2 (Class II Equipment), 1.2.6.4 (Electrical Enclosure), 1.2.8.6 (ELV Circuit), and 2.4 (Limited current circuits).



Questions	Decisions
Is an electrical enclosure (1.2.6.4) requires for Digital Cameras that contain a (Xenon tube) flash, if the flash energy storage capacitor is charged at hazardous voltage?	Yes, an electrical enclosure is required.
What protection class against electric shock should be defined?	A classification is according to 1.2.4 not necessary, but the construction has to provide double or reinforced insulation between hazardous live parts and accessible parts. Marking to Class II is not required.
Is an electric strength test between parts/circuits at hazardous voltage and SELV circuits/ conductive enclosure required (All these parts are commonly connected at one point without insulation (secondary ground)?	An electric strength test is required.

Explanatory Note
If the equipment contains parts and circuits at hazardous voltage, which do mot *[sic]* meet the requirements of LCC or SELV, protection must be provided in form of an electrical enclosure with suitable mechanical strength.

Flash circuit description.

The flash lamp operates when the shutter button is pressed and after the shutter is fully open. The lamp duration is a function of the camera circuits which determine the distance to the subject and the ambient light conditions. An electronic switch determines the flash duration.

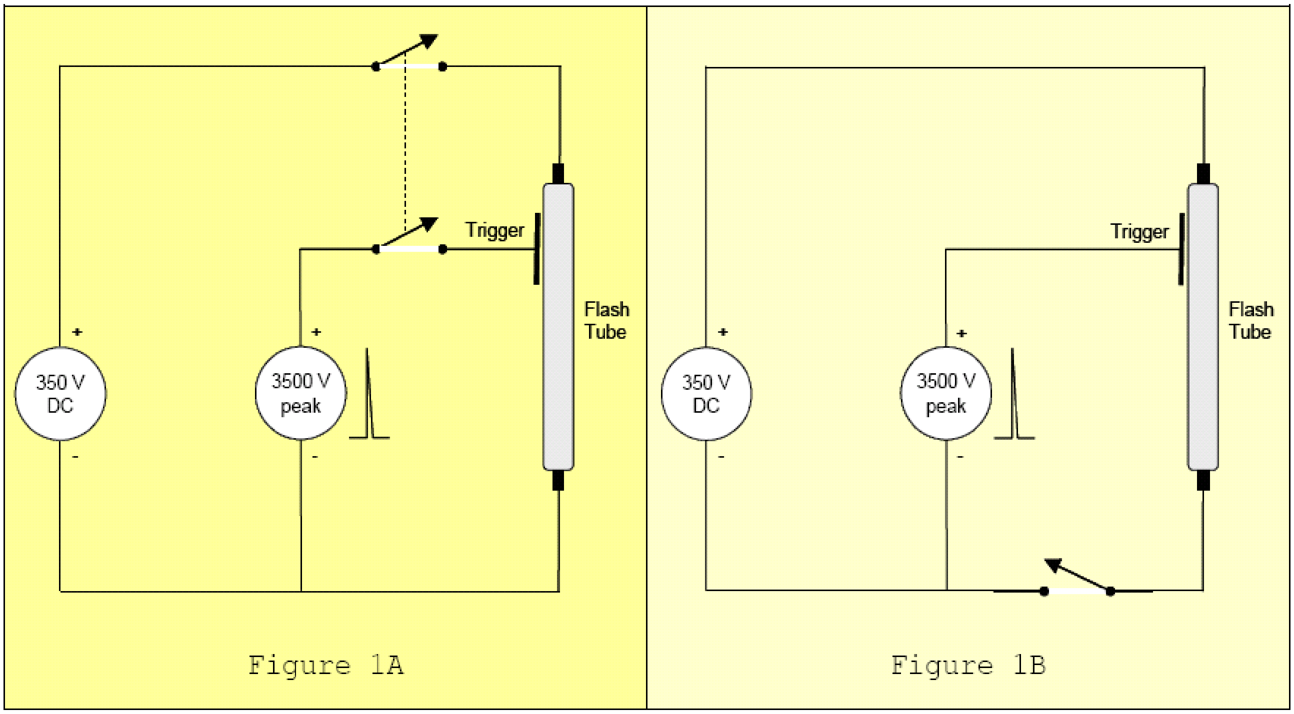
Basically, the flash lamp operates from a dc source of about 350 volts. The lamp is turned on for a few microseconds to a few milliseconds and then turned off. (2)

However, the lamp will not turn on by the 350 volts dc only. The lamp requires a trigger to start the conduction in the lamp. The trigger is a single impulse whose voltage is about 10 times the operating voltage, about 3500 volts.

So, to turn on the flash lamp, both 350 volts DC and a 3500-volt peak impulse are is applied to the flash lamp terminals.

Figure 1A is a simplified schematic of the flash lamp and trigger with separate switches for the DC and for the impulse. Figure 1B is the same schematic, but uses one switch. Later, we'll see that actual flash circuits use one switch as shown in Figure 1B for both the DC and the impulse.

350 volts DC generator.

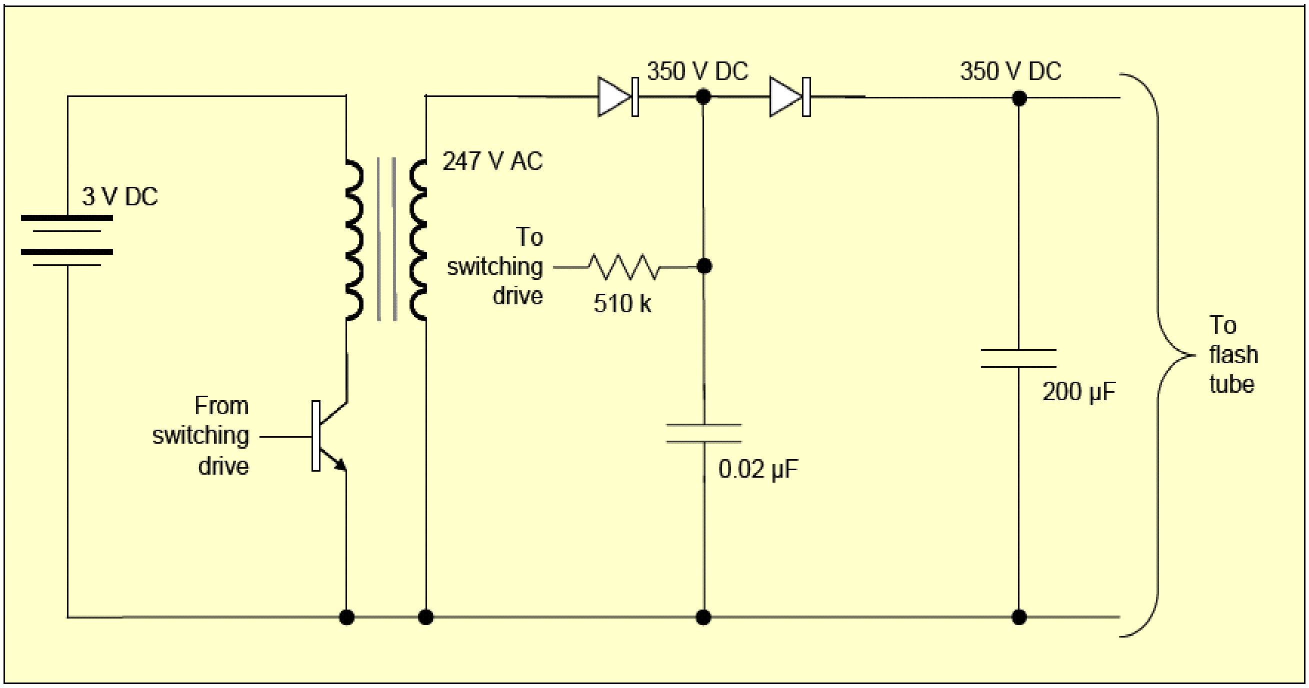


Simplified flash lamp schematic
Figure 1

Let's look at how the 350 volts DC is generated from a pair of 1.5-volt batteries in series (a 3-volt source). This is a very simple high-frequency switching-mode power supply. Figure 2 is a simplified schematic of the 350-volt generator. The input is wimpy and the transformer is both small and wimpy.

Assume the switching frequency is 30 kHz. The transformer output (350 volts peak or about 247 volts rms) is rectified and stored first in a small 0.02 µF capacitor. A feedback circuit monitors this rectified voltage and controls the switching circuit. When the 0.02 µF capacitor is charged, the

Continued on Page 8



Simplified 350 volts DC generator
Figure 2

switching circuit is turned off. The 350 volts DC passes through a second diode and charges a 200 µF capacitor to 350 volts. (The second diode prevents the 200 µF capacitor from discharging through the 510 k resistor to the switching drive circuit.)

Let's examine the high voltage circuits and determine whether they are "limited current circuits" or "hazardous voltage" circuits.

At 30 kHz, a "limited current circuit" is one that does not exceed 30 x 0.7 or 21 mA peak (15 mA rms). If the transformer secondary is 15 mA rms, then the primary or input current must be 10 times that value, 150 mA. 150 mA is a lot of current to be drawing from a battery, and is not a likely scenario. The likely primary current is 50 mA or less.

So, due to the frequency (30 kHz or more) and the small output current (less than 15 mA rms), the transformer output AC is a "limited current circuit." No safeguards are required for the transformer 247 volts rms secondary.

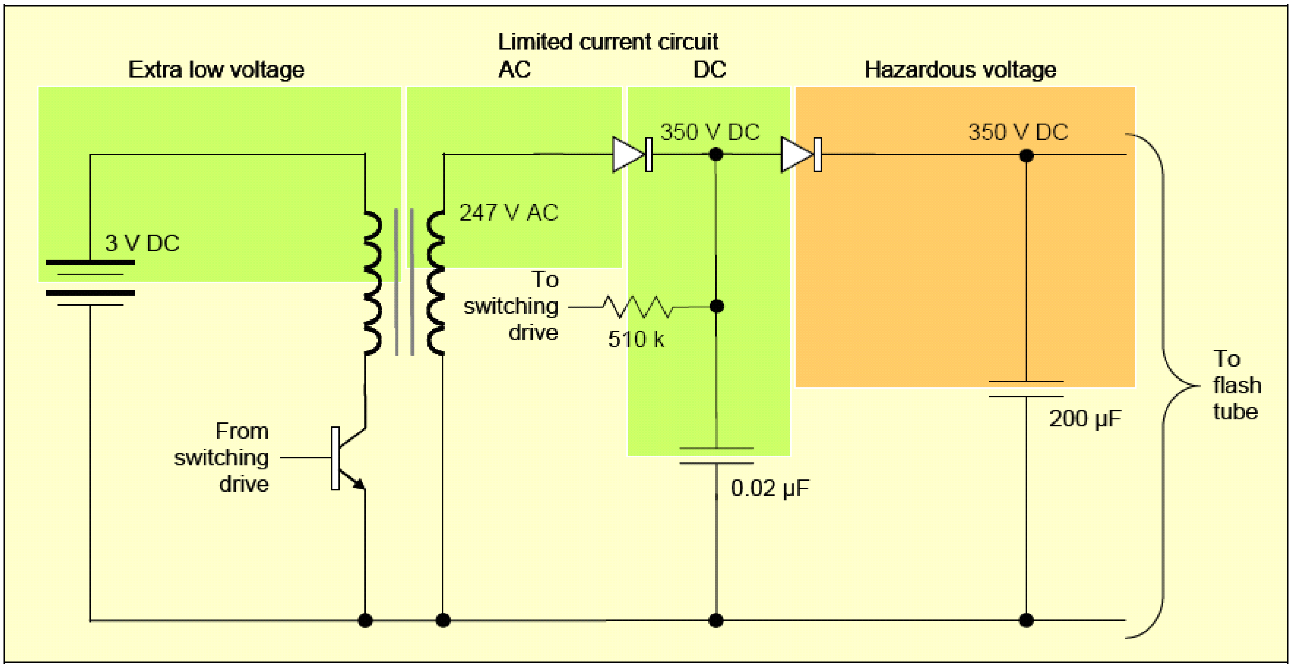
Note that the transformer has a common connection between the primary and secondary windings. Therefore transformer is NOT an isolating transformer. We'll take another look at the transformer when we consider fault conditions.

The rectified voltage (350 volts DC, which is less than 450 volts limit) and the capacitor size (0.02 µF, which is very much less than 0.1 µF limit), comprise a "limited current circuit." No safeguards are required for the 350-volt DC feedback circuit.

The 200 µF capacitor exceeds the 0.1 µF limit. Therefore, the circuit is not a "limited current circuit;" therefore the 200 µF capacitor is a "hazardous voltage" circuit. At least one safeguard must be provided for these conductors. We'll discuss the specifics of the safeguard later.

Figure 3 illustrates the "hazardous voltage" and "limited current circuit" conductors and components of the 350-volt power supply under normal operating conditions. Note also the circuit includes "extra-low voltage." And, note that all voltages are with respect to the common wire. A battery-operated equipment does not have any connection to earth. This will be significant when we look at the electric shock circuit.

IEC 60950-1, sub-clause requires "limited current circuits" to meet the criteria under both normal operating conditions and single fault conditions.



"Hazardous voltage," "limited current circuit" and "extra low voltage" conductors under normal operating conditions
Figure 3

As can be seen in these circuits, component short-circuits are worst-case. Open-circuits are not of any consequence.

Figure 4 illustrates the DC generator "hazardous voltage," "limited current circuit," and "extra-low voltage" conductors and components under single fault conditions. The fault is indicated by the red lightning bolt. The conductors that become "hazardous voltage" as a result of the fault are highlighted in a lighter color.

The switching transistor in the primary circuit switches on and off. So, we need not fault the transistor since its normal operation is both short (on) and open (off). When the transistor is open, there is no current in the transformer primary and therefore no output in the secondary. When the transistor is shorted, DC flows in the primary and therefore no output in the secondary. Conclusion: In the case of a fault of the switching transistor, the current from the "limited current circuit" is 0 mA. So, the AC secondary is a "limited current circuit" under both normal operating conditions and single fault conditions.

The transformer is not an isolating transformer. Nevertheless, we should consider a primary-to-secondary short. When this happens, there is no output because the secondary becomes another primary. In the case of a fault of the transformer, the current from the secondary winding is 0 mA and is a "limited current circuit" under single fault conditions.

If first rectifier diode should fail open, there is no output to the DC "limited current circuit." If the diode

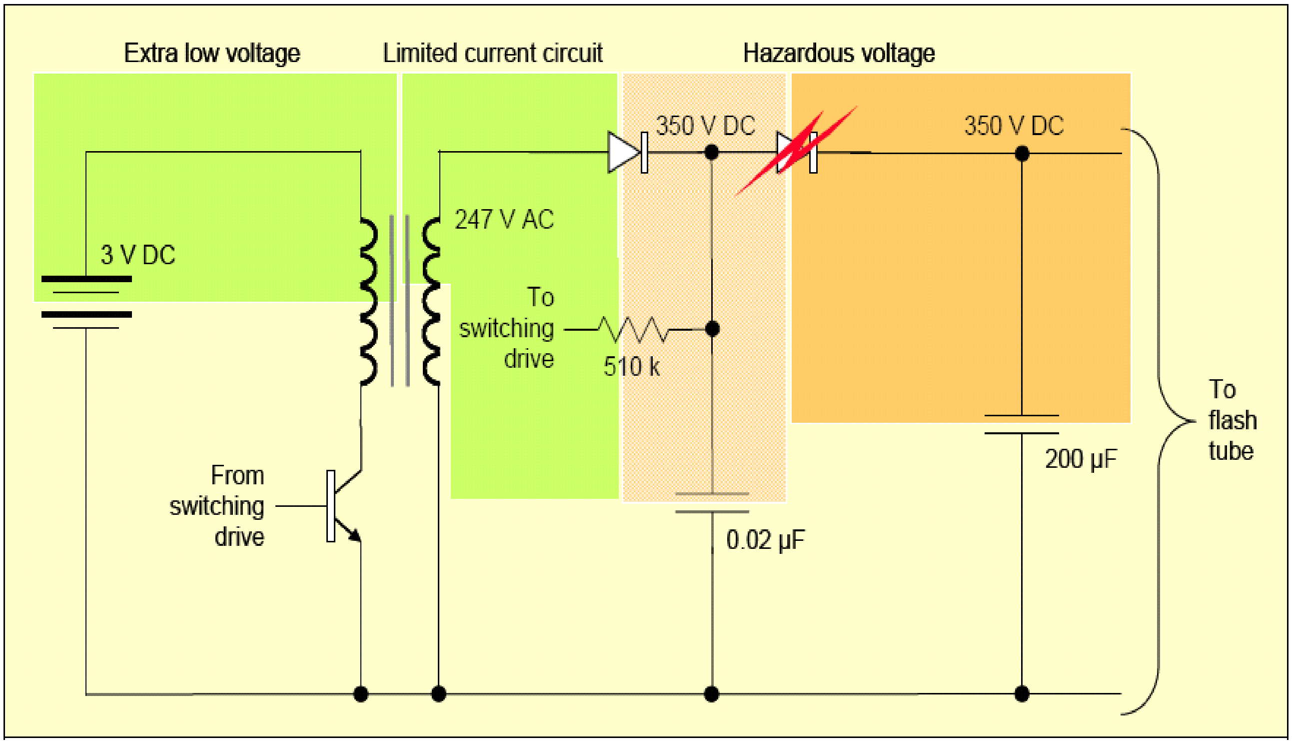
Continued on Page 10

should fail short, then the DC “limited current circuit” becomes an AC “limited current circuit.” In the case of a fault of the first rectifier diode, the current from the “limited current circuit” is either 0 mA (open diode) or less than 15 mA AC (shorted diode) at 30 kHz.

If the second diode should fail open, then there is no output to the 200 µF capacitor and the charge voltage is zero. If the second diode should fail short, then, due to the charged 200µF capacitor, the “limited current circuit” DC on the supply side of the diode becomes “hazardous voltage.” The 510 k resistor between the “limited current circuit” DC and the switching drive circuit renders the switching drive circuit as a “limited current circuit” (I = 350/510 k or 0.7 mA DC). (The limit for a DC “limited current circuit” is 2 mA DC.)

We conclude that, under single fault conditions, the only hazardous voltage circuits are those shown in Figure 4.

3500 volts impulse generator.

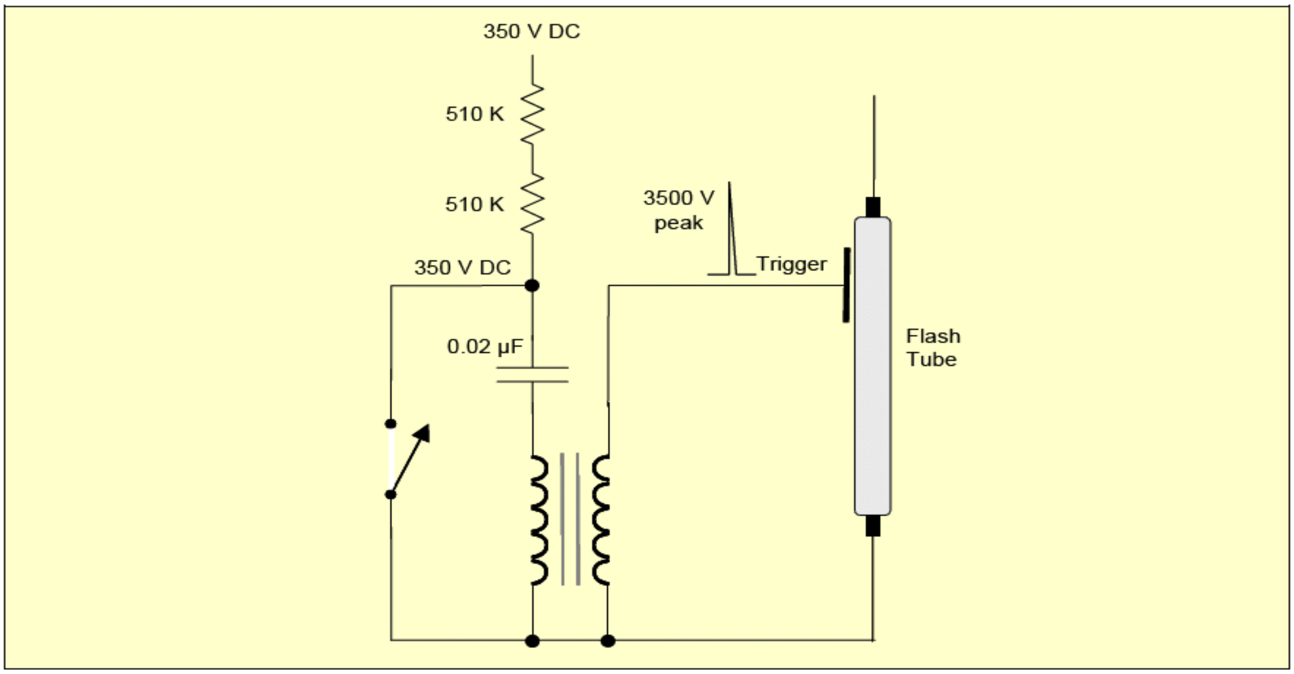


“Hazardous voltage,” “limited current circuit” and “extra low voltage” conductors under normal operating conditions
Figure 4

Now let’s see how the 3500-volt impulse is generated.

The impulse generator circuit, Figure 5, consists of resistors, capacitor, and transformer primary in series. The 0.02 µF capacitor is charged from the 350 volts DC through the two 510 k resistors to 350 volts.

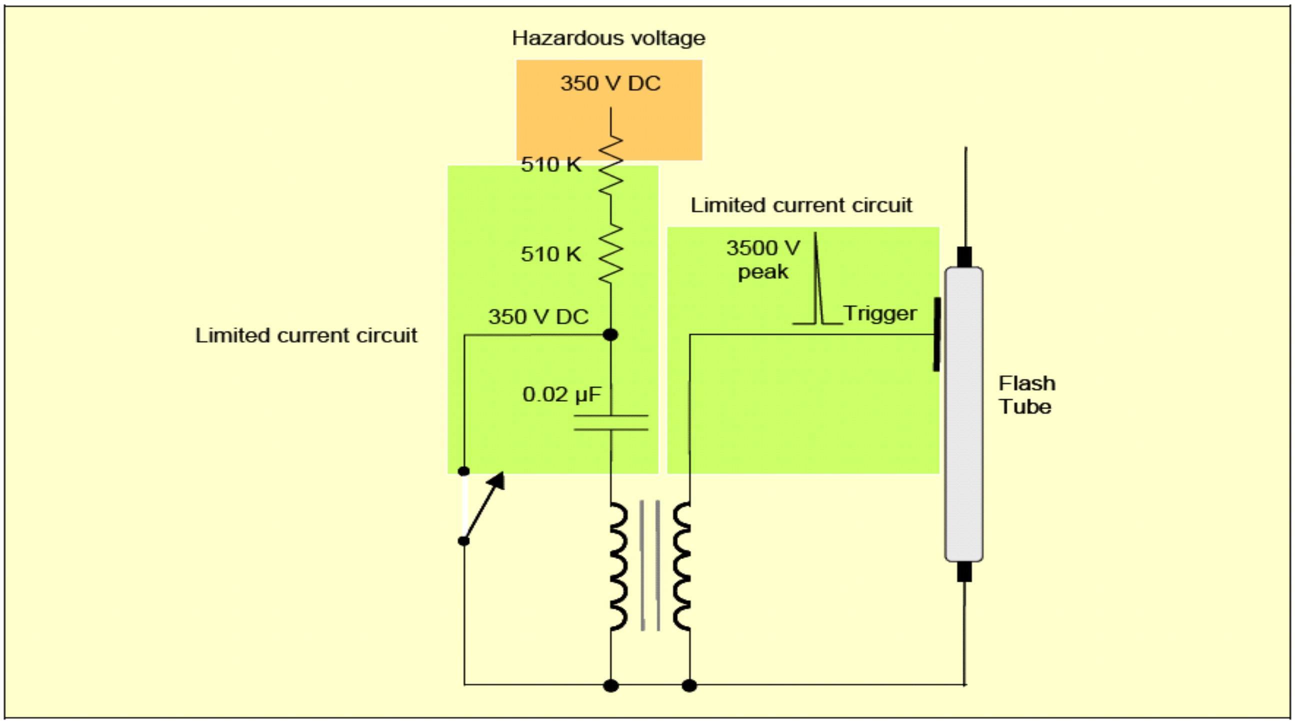
Figure 5 illustrates the trigger impulse generator. When the switch is open, the 0.02 µF capacitor is charged from the 350 volts DC through the two 510 k resistors. The charge is 350 volts. The voltage (350 volts DC) and the capacitance (0.02 µF) are less than the limits of 450 volts and 0.1 µF, so the circuit is a “limited current circuit.”



Simplified trigger impulse generator
Figure 5

When the switch is closed, the 0.02 µF capacitor discharges through the transformer primary. Note that the transformer is not an isolating transformer. The discharge pulse is stepped up in the transformer secondary, applying 3500 volts peak impulse to the flash tube trigger terminal.

Figure 6 illustrates the "hazardous voltage" and the "limited current circuit" conductors of the trigger



Trigger impulse generator "limited current circuit" conductors under normal operating conditions
Figure 6

Continued on Page 12

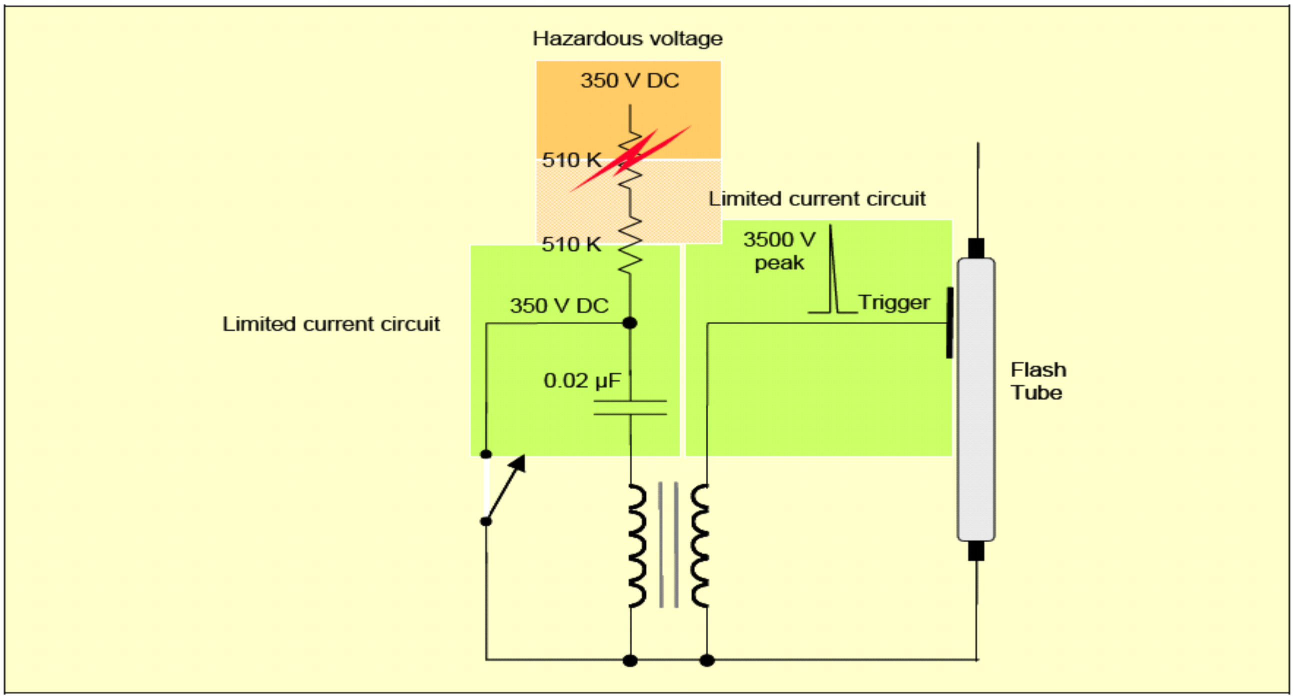
impulse generator.

Note that if the primary is a “limited current circuit,” then so too is the secondary. The total amount of energy in a system is a constant. Therefore, the secondary circuit energy must be the same or less than the primary circuit energy. Therefore, the secondary circuit is a “limited current circuit.” No safeguards are required for the trigger impulse even though it is 3500 volts.

Furthermore, one 510 k resistor limits the current from 350 volts dc to about 0.7 mA DC. The limit for a DC “limited current circuit” is 2 mA DC. So, both the charging circuit and the charged capacitor comprise “limited current circuits.”

Another way to evaluate the 3500-volt trigger impulse generator is to consider an equivalent secondary (high-voltage) circuit. If the transformer is a 1:10 step-up transformer, then the 0.02 µF capacitor as seen from the secondary will appear to be 1/10 of 0.02 or 0.002 µF charged to 3500 volts. For voltages exceeding 450 volts, the capacitance of a “limited current circuit” must not exceed 45/3500 or 0.0128 µF. The reflected capacitance, 0.002 µF is less than 0.0128 µF, so the trigger impulse generator is a “limited current circuit.”

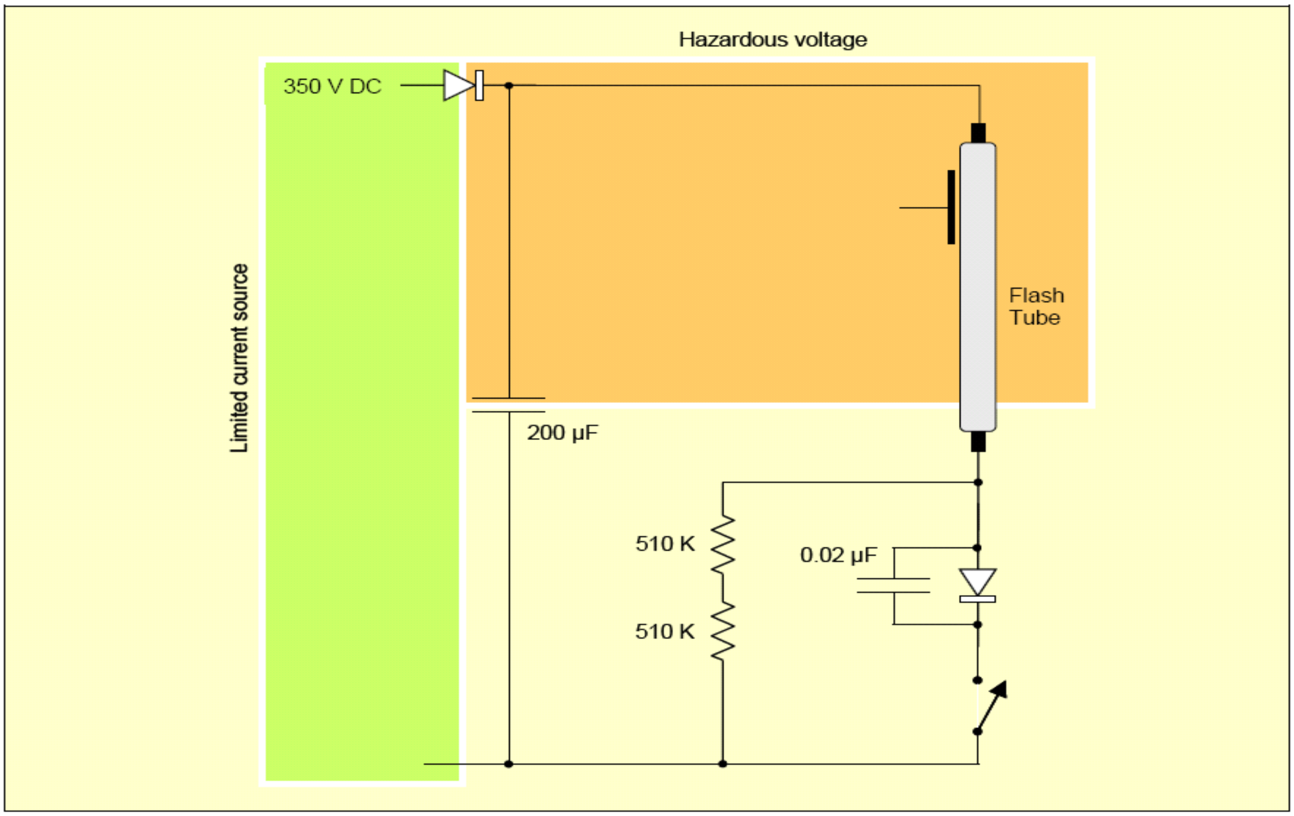
Figure 7 illustrates the “limited current circuits” under single fault conditions. Note that the only fault is the 510 k resistor between the “hazardous voltage” and the “limited current circuit. Only the conductor between the two 510 k resistors is at “hazardous voltage” under single fault conditions. When the first 510 k resistor is shorted, the second 510 k resistor limits the current to the remainder of the circuit.



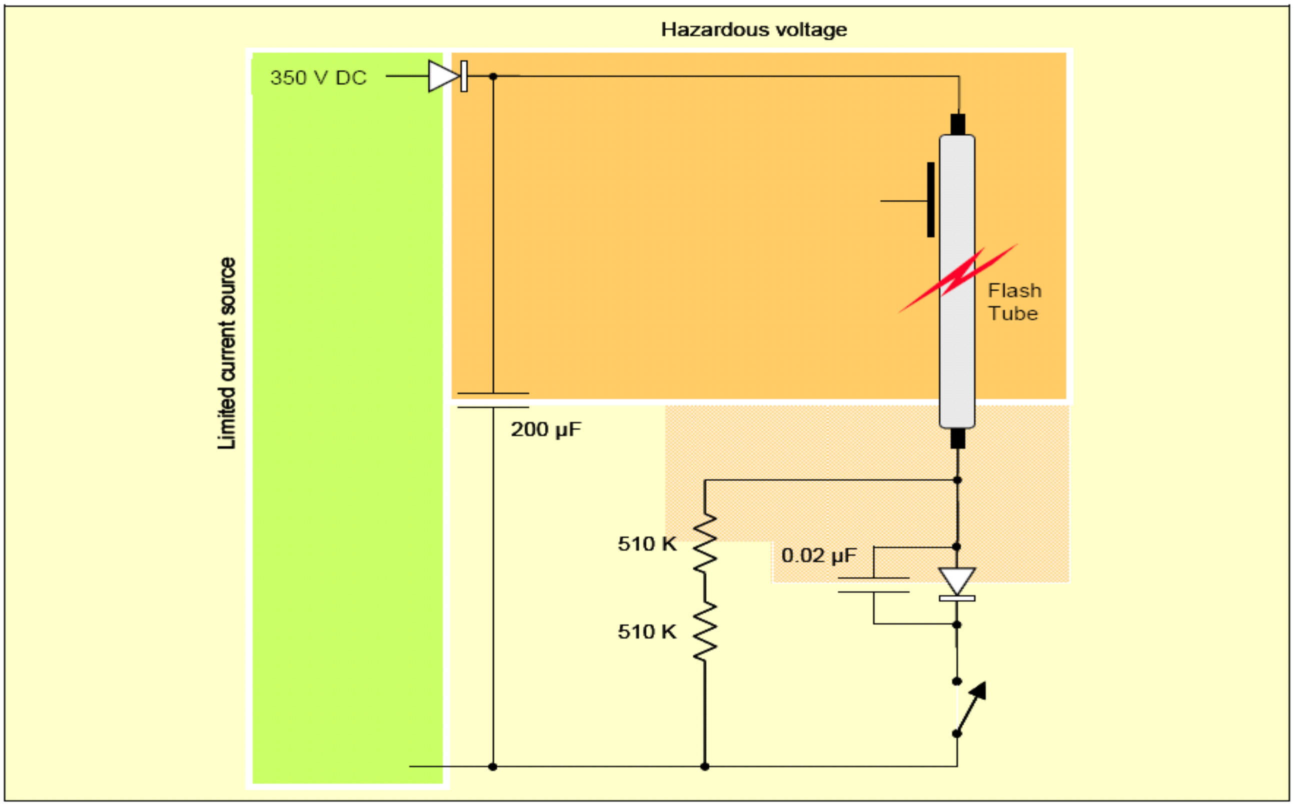
Trigger impulse generator “limited current circuit” conductors under single fault conditions
Figure 7

Flash tube switch circuit.

Now, we’ll examine the circuit that switches the 350 volts DC to the flash tube. See Figure 8.



Simplified flash tube switch circuit
Figure 8



Flash tube switch circuit "hazardous voltages" under single fault conditions
Figure 9

Continued on Page 16

We've got you covered!

It's time to relax and enjoy the fruits of your daily efforts! The IEEE Financial Advantage Program provides the solutions you need to take control of your life and maintain your independence – whether you are starting a business at home, investing for today or for retirement, planning a dream vacation, or all of the above!

IEEE Financial Advantage Program representatives will answer questions and guide you to more detailed information. Let them help you find the programs that are right for you:

- **Insurance Programs**
- **Home Services**
- **Financial Services**
- **Business Services**

In the US and Canada

Call +1 800 GET IEEE (438 4333)

Outside the US and Canada call +1 732 981 0060

IEEE FINANCIAL ADVANTAGE PROGRAM®

All your solutions under one roof!

Visit www.ieee.org/fap
Email fap-benefits@ieee.org

IEEE

NARTE®

The Internationally Recognized Certification Program for Engineers and Technicans

- PUT YOUR CAREER ON THE FAST TRACK
- GIVE YOUR COMPANY CERTIFIED EXCELLENCE
- OFFER YOUR CUSTOMERS EXCEPTIONAL VALUE

UK: NARTE, Astonbury Manor, Suite 9, Stevenage, SG2 7EH, UK • +44 (0)1438 880757: NARTEinEu@aol.com
Japan: KEC, 6-8-7 nishitenma, kit-ku, Osaka-city 530-0047, Japan • +81-6-6364-2341: kudo@kec.jp
USA Headquarters: NARTE, 167 Village Street, Medway, MA 02053, USA • +1 800-89-NARTE: info@narte.org

For complete information, certification enrollment forms and course study materials, log on to: **www.narte.org**

IEEE PSES Membership savings

UL University Offers
IEEE PSES Members
15 Percent Discount

UL University (ULU) has established a discount code which will provide all IEEE-PSES members with a 15 percent discount off the price of all ULU instructor-led workshops, online programs, videos, books, and other services/products offered under the ULU brand. The discount is automatically applied during registration or purchase of ULU products. Registration or product purchase can be accomplished online at www.uluniversity.com or by calling 888-503-5536 in the U.S. or the country-specific number posted on the ULU website.

To receive the discount, members must enter or mention the discount code found in the Members Only section of the PSES website.

If you or any member has specific questions regarding ULU products or services, please call or email me or call the local country specific number posted on the UL University website.

Tony Robertson
Manager – Customer Training

Advantages of Membership in the IEEE PSES

Makes you part of a community where you will:

- Network with technical experts at local events and industry conferences.
- Receive discounts on Society conferences and symposiums registration fees.
- Participate in education and career development.
- Address product safety engineering as an applied science.
- Have access to a virtual community forum for safety engineers and technical professionals.
- Promotion and coordination of Product Safety Engineering activities with multiple IEEE Societies.
- Provide outreach to interested engineers, students and professionals.
- Have access to Society Publications.

IEEE | PSES Product Safety Engineering Society

E-Mail List: http://www.ieee-pses.org/emc-pstc.html
Virtual Community: http://www.ieeecommunities.org/emc-pstc
Symposium: http://www.ieee-pses.org/symposium/

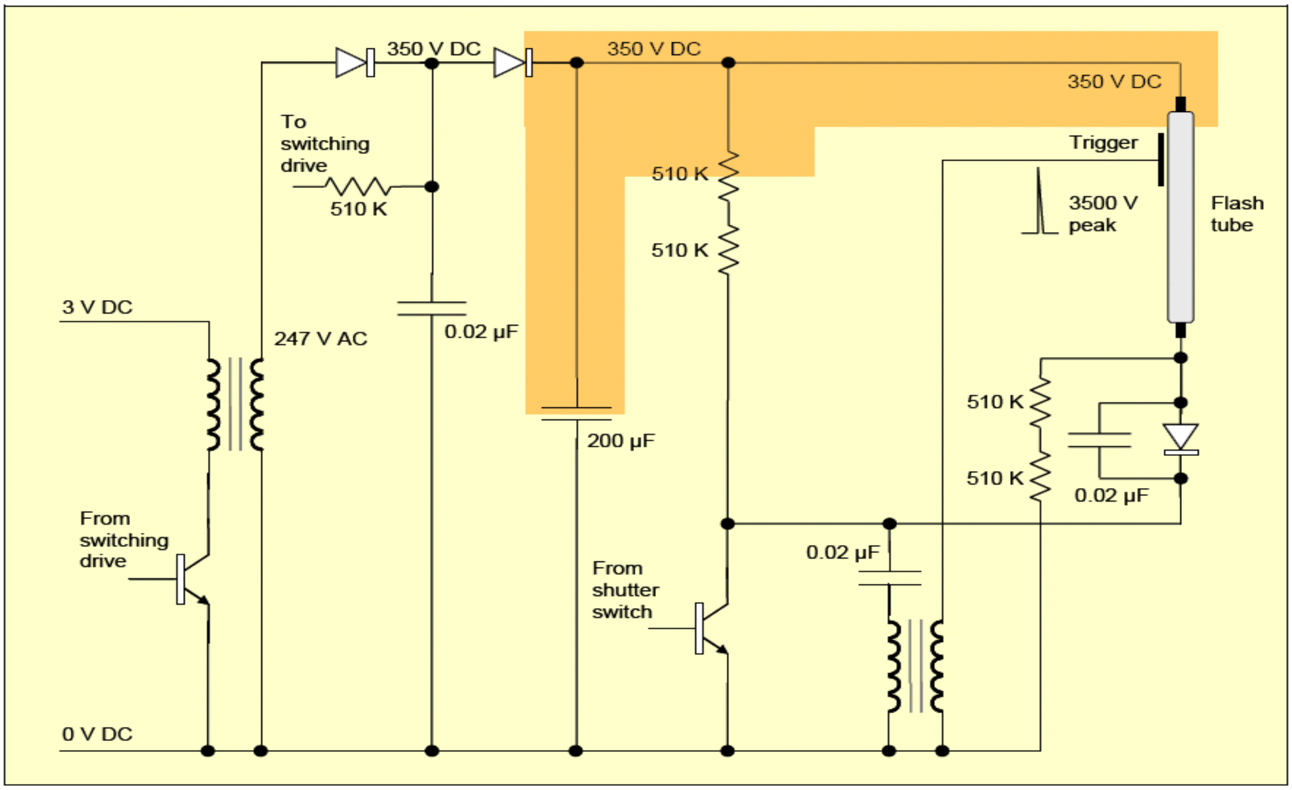
Membership: The society ID for renewal or application is “043-0431”. Yearly society fee is US $35.

The 350 volts DC is connected to one end of the flash tube. When the switch is closed the energy stored in the 200 µF capacitor is discharged into the flash tube. (The 350 volts DC supply is too wimpy to supply the current required for operation of the flash tube.)

Figure 9 illustrates the single fault conditions of the flash tube circuit. The only fault in this circuit is the flash tube itself. (We considered the diode fault in the DC generator description.) Whether the flash tube can fail short is doubtful. The tube is xenon gas filled glass with electrodes at each end. The trigger terminal is a metal electrode attached to the glass, typically a tube mounting device. To fail short, the flash tube glass would need to break and the end electrodes would need to come together. Nevertheless, for the purpose of this discussion, we will consider that the flash tube can short end-to-end.

Complete flash circuit.

Complete flash circuit showing hazardous voltage conductors under normal operating conditions

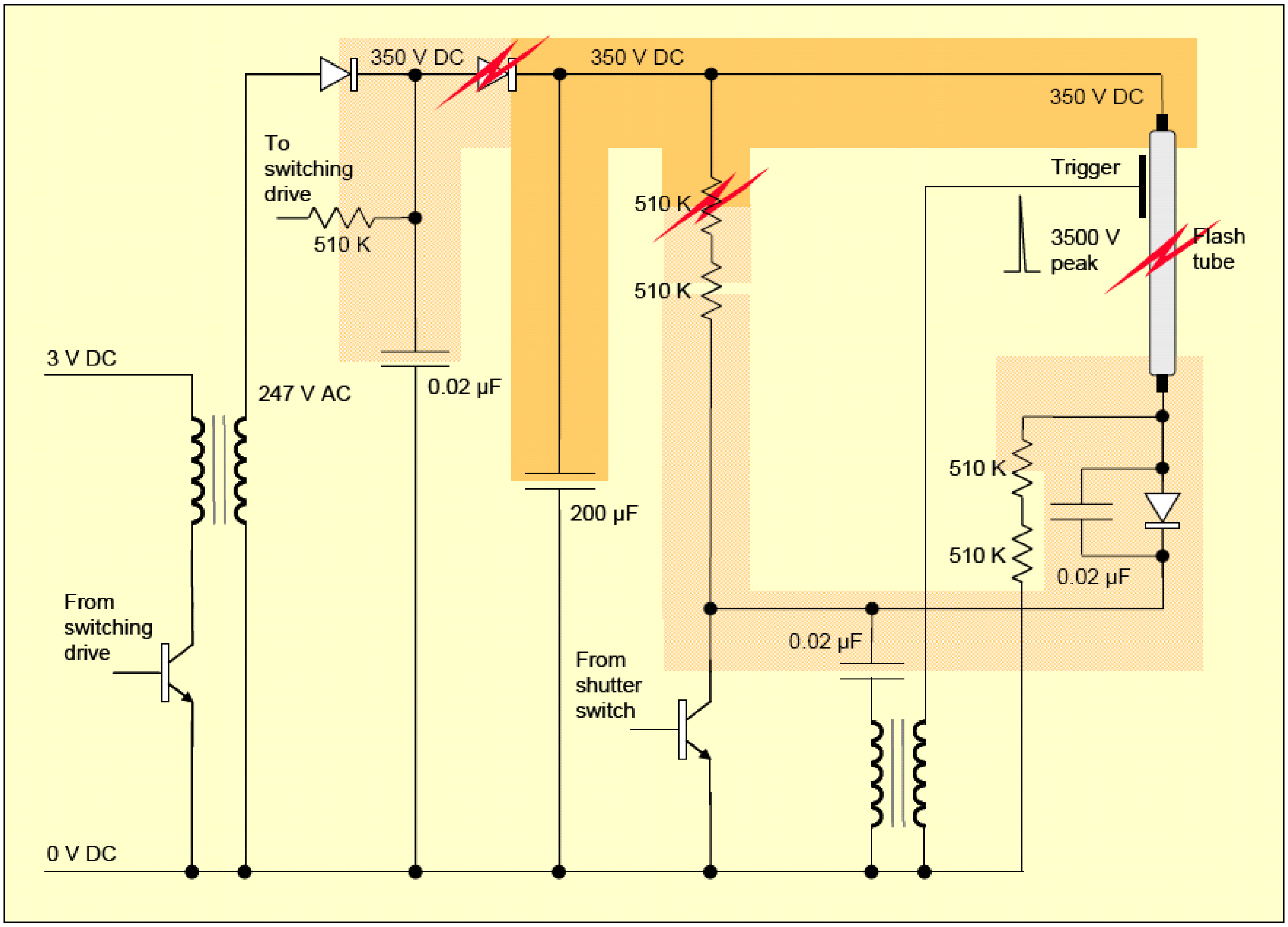


Complete flash circuit showing hazardous voltage conductors under normal operating conditions
Figure 10

Figure 10

Note that hazardous voltage only exists due to the charged 200 µF capacitor. Under normal operating conditions, only those conductors connected to the positive terminal of the 200 µF capacitor comprise hazardous voltage. All other conductors are either “limited current circuit” or “extra-low voltage” as illustrated in previous figures.

Figure 11 illustrates the “hazardous voltage” conductors (in light color) due to the single fault conditions indicated by the red flashes.



Complete flash circuit showing faulted components and “hazardous voltage” conductors
Figure 11

The diode fault and the flash tube fault provide a discharge path for the 200 µF capacitor. We can easily calculate the capacitor voltage as a function of time. A time constant is the time to discharge to 37% of the charge voltage and is defined as R x C. If the diode should short, then the time constant to 37% of 350 volts (about 130 volts) is 200 µF multiplied by 0.51 megohm or about 100 seconds. The time to 37% of 130 volts (47 volts) is also about 100 seconds. So the total time to 47 volts is about 200 seconds or about 3.3 minutes. Likewise, if the flash tube should short, the time to discharge through 1.2 megohms (510 k + 510 k) to 47 volts is about 6.6 minutes. So, the safeguards against these two faults need only be effective for about 6.6 minutes after the fault.

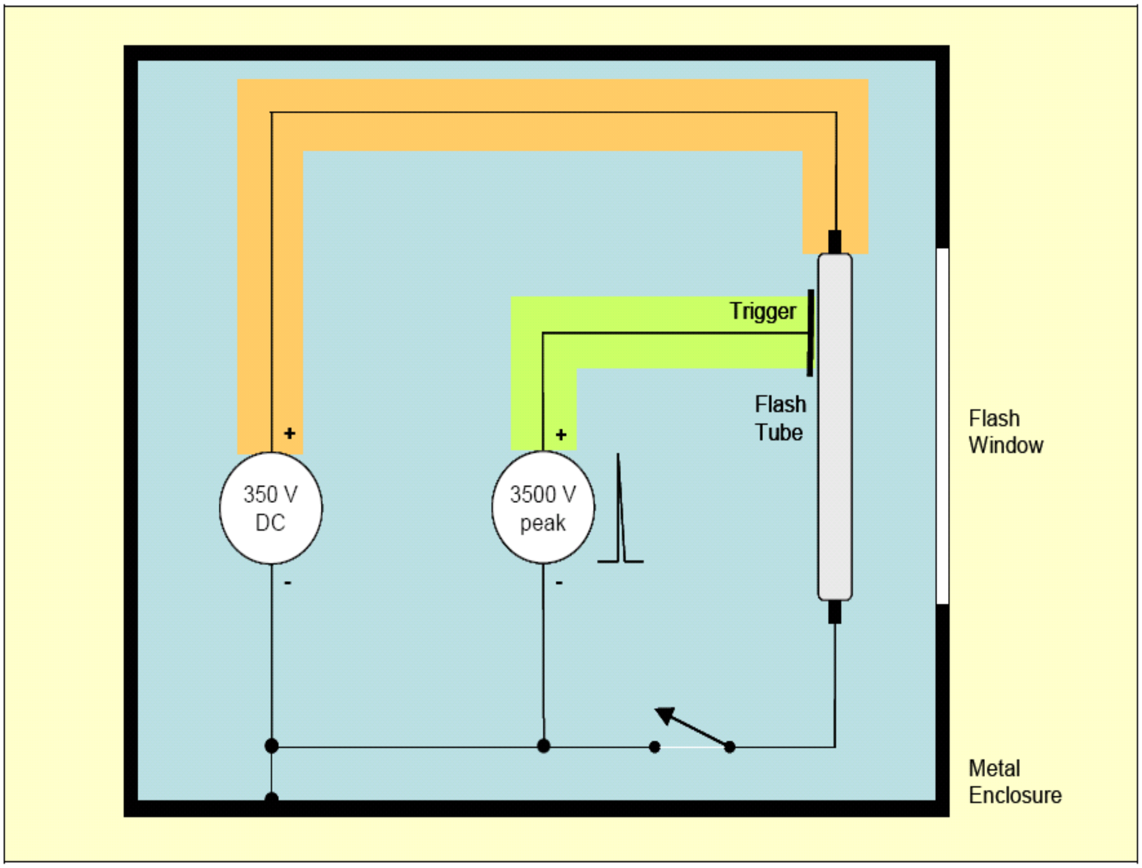
I suppose that the flash tube could fault to the trigger. If this should occur, it is of no consequence because the trigger is connected to the circuit common point through the transformer, and would discharge the capacitor immediately.

Safeguards.

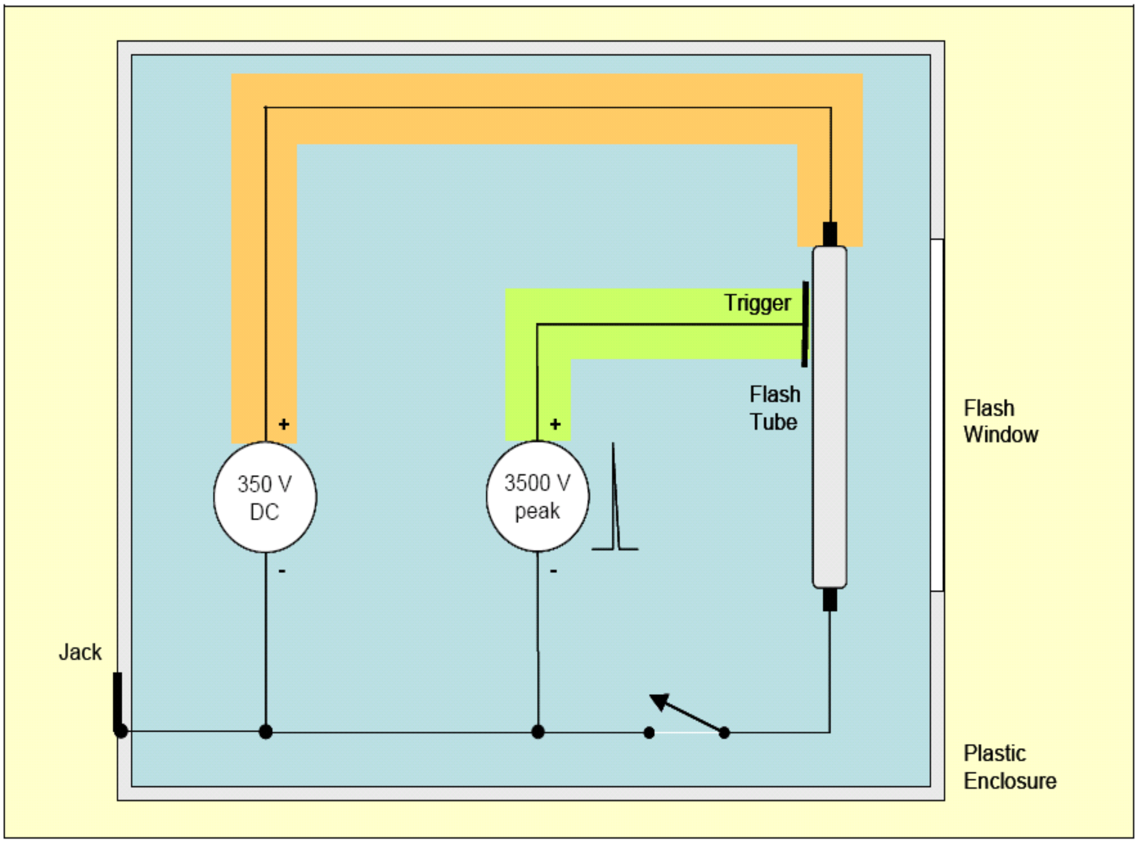
Now that we’ve identified the “hazardous voltage” conductors, we can apply safeguards to prevent electric shock from those “hazardous voltages.”

Cameras use both metal and plastic enclosures. We’ll examine both cases. Now that we know the circuit details we can go back and use the simplified schematic diagram to understand where to apply safeguards. See Figures 12A and 12B.

Continued on Page 18



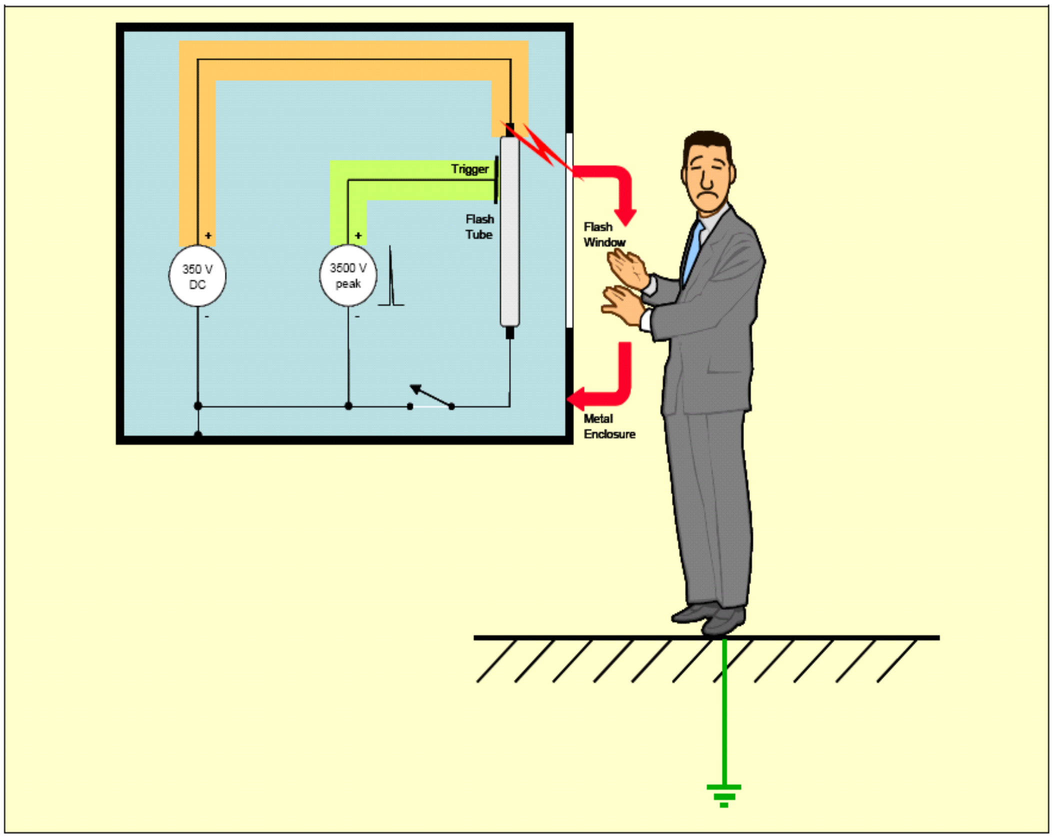
Simplified flash circuit inside metal enclosure
Figure 12A



Simplified flash circuit inside plastic enclosure
Figure 12B

Figures 12A and 12B, illustrate the simplified schematic (with the “hazardous voltage” identified) within the camera enclosure. 12A is a metal enclosure; 12B is a plastic enclosure. Both enclosures have a flash tube window (or lens) of clear plastic that completely fills an aperture in the overall enclosure.

Figures 13A and 13B illustrate the current path for an electric shock from the charged 200 µF capacitor conductors via fault between the flash tube terminal and through the flash window. Note there is no current path though the earth. The current path is between the fault site (the flash window) to the metal enclosure of the camera.



Electric shock current path, metal enclosure
Figure 13A

To prevent electric shock in this scenario, the insulation between the flash tube terminal and the flash tube window must be basic insulation. In addition, the construction must provide protection in the event of a fault of basic insulation. Fault protection requires supplementary insulation. So, the insulation must be double or reinforced.

Now, we need to determine the required parameters for clearance, creepage distance, and distance through insulation.

Continued on Page 20

Clearance.
Sub-clause 2.10.3.3 is for clearances in secondary circuits, including a battery circuit. We want to know the clearance between the flash tube terminal and a point that is accessible. From Table 2K we learn that a reinforced insulation clearance for DC voltages exceeding 280 and up to 420 (not subject to transient overvoltages) is 2.8 mm. Typical camera flash tube construction does not have a direct clearance between the flash tube terminal and a body part (i.e., a finger). Instead, the clearance snakes around the flash tube mounting then through air to the flash tube window, and then through the joint between the enclosure and the flash tube window.

By the way, I want to make two points on standards versus physics. First, according to Paschen's Law(4), air does not break down below about 350 volts peak or DC. Therefore, despite the safety standards, clearance requirements for voltages up to about 350 volts DC can be as little as practicable. Second, according to IEC 60664-1(5), the minimum clearance for 350 volts DC withstand is 0.012 mm.

Creepage distance.

Sub-clause 2.10.4 specifies the creepage distances. Creepage distance is a function of three factors: 1) working voltage; 2) pollution degree; and 3) material comparative tracking index, CTI. Depending on pollution degree and CTI, reinforced insulation creepage distance for 350 volts DC can be as little as 2.8 mm to as much as 12.6 mm.

If the pollution degree within the camera body is 1, then the creepage distance is the same as the clearance, 2.8 mm, regardless of CTI.

However, 2.10.1 states that pollution degree 2 is generally applicable to equipment within the scope of the standard. In this case, the minimum required creepage distance, depending on CTI, varies from 4 mm to 8 mm.

Typical construction of flash tube mounting would entail at least one solid insulation to support the flash tube terminals and another solid insulation for the flash tube window. Both of these insulators would be mounted to a common part, which may or may not be an insulator. The creepage distance path would be the shortest distance between the flash tube terminal and conductor and the closest approach of a body part (finger) at a joint between the flash tube window and the camera body. The required creepage distance should be readily accomplished in the design.

Distance through solid insulation.

According to 2.10.5.1, the minimum distance through solid reinforced insulation is 0.4 mm.

Electric strength of solid insulation.

Sub-clause 5.2.2 invokes Table 5B. For secondary circuits with 350 volts DC working voltage, Note 5 specifies use of the table for DC derived within the equipment from AC supplies or DC derived from equipment within the same building. There is no requirement for DC derived within the equipment from a battery source.

We don't want to use the test voltage for 350 volts DC for reinforced solid insulation in accordance with Part 1 of Table 5B. If we did, the specified test voltage is 2,359 volts rms! This would require a clearance of about 3.5 mm, considerably more than the 2.8 mm determined from Sub-clause 2.10.3.3.

If we work backwards from 2.8 mm using IEC 60664, the withstand voltage for 2.8 mm is about 2100 volts rms. Supposedly, 2.8 mm should withstand 2100 volts rms.

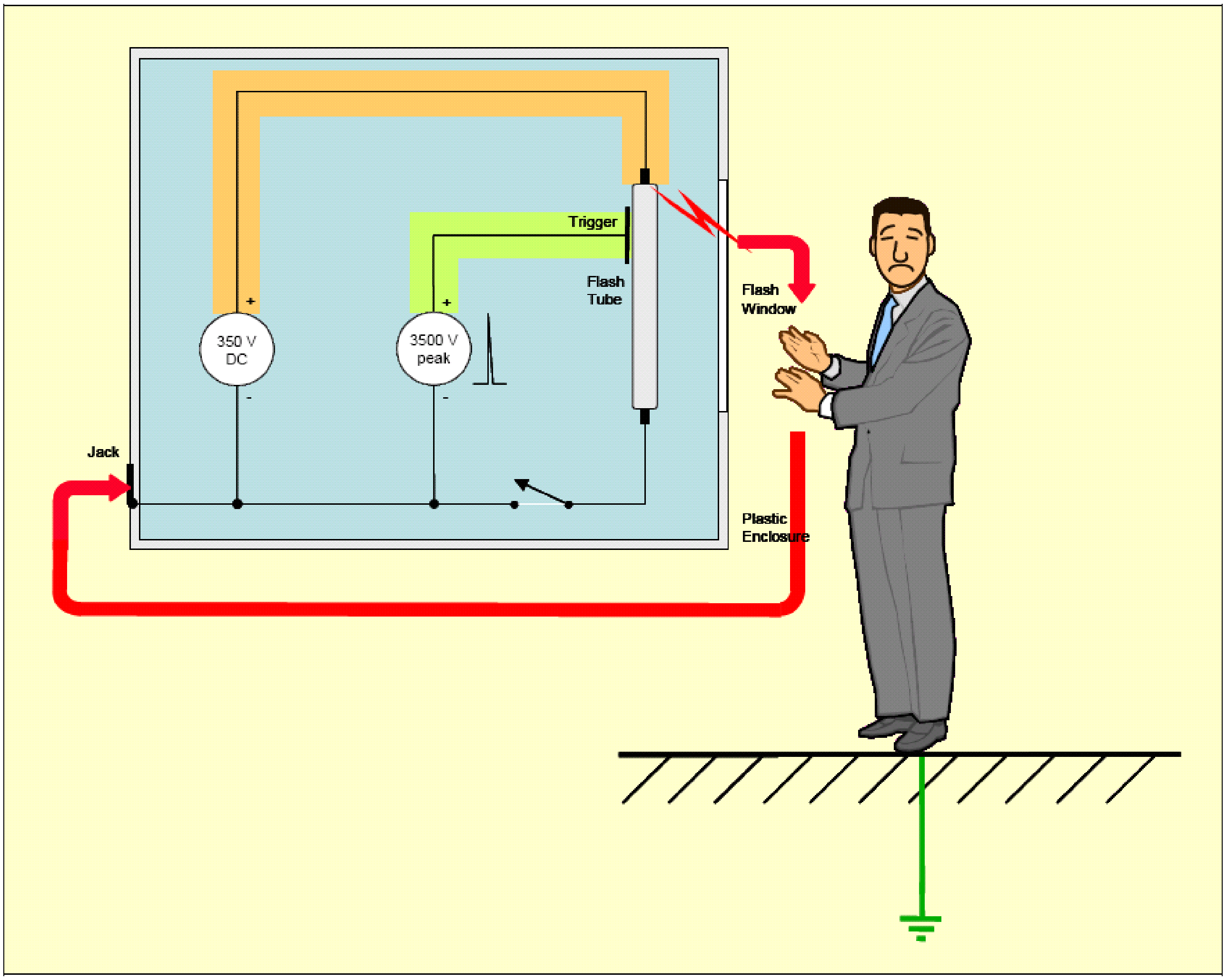
However, both 2.8 mm and 2100 volts rms are excessive for 350 volts DC that has no transient overvoltages. The standard does not have any appropriate clearance or electric strength requirements for this construction.

Insulation between flash tube terminal and metal enclosure.

One way to determine whether an insulation is a safeguard is to fault (short) the insulation. If the result is a circuit path through the body (as shown in Figure 13A), then the insulation must be a safeguard.

On the other hand, if the fault does not result in a circuit path through the body, then the insulation is functional insulation. In Figure 13A, if a fault should occur from the flash tube terminal to the metal camera case, then the capacitor is discharged through the camera enclosure; there is no circuit path through the body.

In this case, the insulation is functional and the metal camera enclosure is the safeguard (because



Electric shock current path, plastic enclosure
Figure 13B

Continued on Page 22

it returns the fault current to the capacitor). The camera enclosure must be capable of carrying the discharge current for the duration of the discharge. This can be verified by a simple test of shorting the 350 volts DC to the camera enclosure.

Safeguards – plastic enclosure.

Figure 13B illustrates the current path for an electric shock from the charged 200 µF capacitor conductors via fault between the flash tube terminal and through a seam in the plastic enclosure. Note that this scenario is the same as for a fault between the flash tube terminal and the flash window.

To prevent electric shock in this scenario, the requirements for the plastic enclosure are exactly the same as for the flash tube window discussed for the metal enclosure. We need not repeat this discussion.

Summary.

Now let's review the CTL questions and decisions.

Question #1: Is an electrical enclosure (1.2.6.4) requires *(sic)* for Digital Cameras that contain a (Xenon tube) flash, if the flash energy storage capacitor is charged at hazardous voltage?

Decision #1: Yes, an electrical enclosure is required.

Our opinion #1: *We have proved that, due to the charging of a 200 µF capacitor, hazardous voltage is generated. Therefore, an electrical enclosure is necessary. We agree with the decision.*

Question #2: What protection class against electric shock should be defined?

Decision #2: A classification is according to 1.2.4 not necessary, but the construction has to provide double or reinforced insulation between hazardous live parts and accessible parts. Marking to Class II is not required.

Our opinion #2: *The camera is not Class I because it is not grounded. The camera is not Class II because it does not require double insulation for a metal enclosure, but is Class II for an insulating enclosure. The camera is not Class III because it has hazardous voltage. For the solid insulation (plastic) parts of the enclosure, the construction requires double or reinforced insulation with respect to the hazardous voltage. We agree with the decision.*

Question #3: Is an electric strength test between parts/circuits at hazardous voltage and SELV circuits/conductive enclosure required (All these parts are commonly connected at one point without insulation (secondary ground)?

Decision #3: An electric strength test is required.

Our opinion #3: *We agree that an electric strength test is required between the hazardous voltage and the flash window together with accessible surfaces of a plastic camera enclosure. However, the standard does not specify a test voltage for DC secondary circuit construction that is not subject to transient overvoltage. Moreover, clearance, creepage distance, and distance through solid insulation must comply with the standard. An electric strength test is not required between the hazardous voltage and a metal enclosure. A fault test from hazardous voltage to the metal* *enclosure should be conducted to verify that the discharge circuit can withstand the discharge current. While we agree with the decision, the standard does not specify a suitable test voltage.*

Explanatory note: If the equipment contains parts and circuits at hazardous voltage, which do mot *(sic)* meet the requirements of LCC or SELV, protection must be provided in form of an electrical enclosure with suitable mechanical strength.

Our opinion: *We agree that the camera enclosure is an electrical enclosure and must have suitable mechanical strength.*

*****

If you have any comments or questions about this article, please send them to Richard Nute, richn@ieee.org.

If you have a question about safety, and would like to see the answer published here, please send the question to Richard Nute, richn@ieee.org

References.

(1) http://www.iecee.org/ctl/CTL_decisions.htm

(2) For a more detailed explanation of flash lamp operation, see http://members.misty.com/don/samflash.html#strbpoo

(3) For more flash unit safety, see: http://members.misty.com/don/xesafe.html

(4) For more information on Paschen’s Law, see: http://home.earthlink.net/~jimlux/hv/paschen.htm

(5) IEC 60664-1, Edition 1, Annex A1, Table A1. Also, IEC 60664-1, Edition 2, Annex A, Table A.1.

SAFETY CONSIDERATIONS FOR LIQUID FILLED HEAT SINKS

BY: LAL BAHRA P. ENG.
DELL INC.

Introduction

The basis for applying safeguard requirements to Information Technology Equipment (ITE) containing liquids is the requirement in sub-clause 4.3.10 of IEC 60950-1, which states the following:

> Equipment producing dust (e.g. paper dust) or using powders, liquids or gases shall be so constructed that no dangerous concentration of these materials can exist and that no hazard in the meaning of this standard is created by condensation, vaporization, leakage, spillage or corrosion during normal operation, storage, filling or emptying. In particular, Creepage distances and Clearances shall not be reduced below the requirements of 2.10.

In addition, sub-clause 4.3.11 states:

> Equipment that, in normal use, contains liquids or gases shall incorporate adequate safeguards against build-up of excessive pressure.

The above subclauses provide very general guidelines and do not completely specify the required safeguards and safeguard requirements. We need to look into other standards which address equipment that use pressurized and non-pressurized liquid containment vessels and address compatibility issues when plastic materials are used in conjunction with liquids.

Product sizes are continuously being reduced and integrated circuit (IC) chips are becoming more compact containing more and more components. They are also going up in processing speeds. Products that try to keep up with new technology need more power and as a result, generate more heat in the equipment. This heat must be moved out of the product. There are many different types of systems available for cooling (moving heat out of the product). We are going to discuss mainly two types of liquid cooling systems here:

NOTE – This article does not discuss EMC, ROHS or acoustic considerations. These should be taken into account as applicable.

Liquid Cooling Heat Pipes

A heat pipe can quickly transfer heat from one point to another (see Figure 1). It works on the principle that if there is a difference in temperature at two ends of the heat pipe, the heat can be taken away from that point to the other end. It consists of a sealed metal hollow pipe (container) whose inner surface has a capillary wicking material (wick) and the cooling liquid. It transfers heat by evaporation and condensation cycle with the help of porous wicking material. When one end is hot, the liquid evaporates (that reduces the temperature of the hot part) and vapor travels to the other end where it condenses (releasing the heat). The wick provides the capillary action to bring the liquid back to the evaporator. These types of devices contain a very small amount of liquid that is mainly contained in the wicking material. The working pressure inside the heat pipe is equal to the vapor pressure of the liquid (for example, the vapor pressure of Ammonia is 1554 kPa at 40 ^{o}C; and vapor pressure of water is 7.37 kPa at 40 ^{o}C). Vapor pressure is higher at high temperatures. Most commonly used liquids are ammonia and water. The leakage of liquid is not of concern here because even if there is a leak, spillage is mostly vapor when the unit is operating and not more than a few drops when unit is in the cold condition. The safeguards required by safety testing agencies for pressure testing of these heat pipes are (1) there should be no leakage under normal operating conditions, abnormal operating conditions and single fault conditions; (2) a cycling test at 10 °C higher than the actual temperature of the hot part; and (3) the liquid to be nonconductive, non-flammable, non-corrosive and non-toxic. The combination of the above three tests constitutes a reinforced safeguard for testing the heat pipe (as the heat pipe has to perform successfully under single fault conditions and also at a temperature that is 10 °C higher than the maximum temperature developed under single fault conditions). The cycling test insures that there would not be any leakage (as the equipment will see only a lower temperature than that). In the case of any leakage if it occurs, the liquid requirements insure no fire or injury from the coolant (agencies do not conduct any pressure test).

Note: References to the websites mentioned in this article are for information only and exist as of the date of this article and reference to any website in no way implies any kind of endorsement.

See the following URL for a further description of a heat pipe.

http://www.cheresources.com/htpipes.shtml

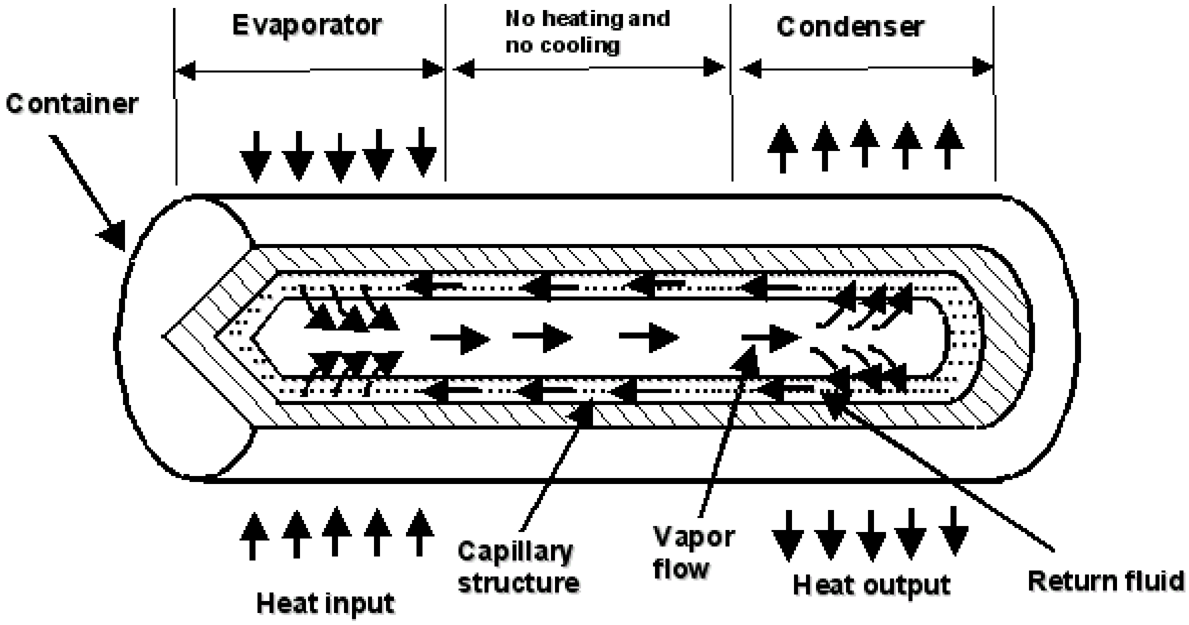


Figure 1: Heat pipe heat flow and liquid flow

Liquid filled heat sink system (LFHS)

Liquid filled heat sink systems typically consist of a fan, pump, radiator type heat exchanger, an optional thermoelectric cooler (TEC), tubing, fittings, a controller PWB, cooling liquid, heat sink plate and associated wiring (see Figure 2). Sometimes a refrigerating unit may also be added. An LFHS for use in IT equipment such as desk tops and servers contains lot more liquid than a heat pipe. The amount of liquid in a heat pipe is only a few mL whereas an LFHS contains anywhere from 250 mL to a liter of liquid. If a spill or leak occurs in an LFHS, and because there is much more liquid than in a heat pipe, it follows that there may be a risk of electrical shock (because the conductive or partially conductive liquid may bridge an accessible conductive part to a part at a hazardous voltage), fire

Continued on Page 26

(the leaked flammable liquid may get hot and ignite) or chemical hazard (the liquid may be toxic) depending upon the location, flame properties and toxicity of the liquid.

There are two major types of LFHS systems available on the market, refillable and sealed type systems.

A refillable system requires the user to replace the liquid at regular intervals. In doing so, there is a possibility of user error in (1) removing the old liquid from the LFHS; (2) cleaning; (3) refilling the liquid; and (4) restoring the equipment to its original condition. Errors in these activities may lead to spillages or leakages. Since the LFHS temperature and pressure both build up during the operation of the equipment (the temperature rises due to thermal energy dissipation and the hot liquid evaporates to generate higher pressure), there is a possibility of a leak which may result in possible hazards.

A sealed system is where a definite quantity of liquid cooling agent is sealed under vacuum to ensure that the pressure inside the LFHS is at the vapor pressure of the liquid. The filling and sealing is done at the factory by the manufacturer. This results in a better LFHS that will not spill or leak as the manufacturing is conducted under tight quality control programs. In addition a pressure test is conducted as a routine test to test for any leaks. A sealed system is a preferred system as the possibility of a leak is greatly reduced.

Refillable and sealed LFHSs are used in desk top units or stationary equipment and in printers. Refillable LFHSs are not recommended for use in any portable equipment where orientation may change for the reasons given previously (unless the product is tested in all such orientations after a number of refilling cycles expected to occur during the life of the product). If the LFHS is of a sealed type construction, then the system is orientation proof (this should not be a concern but a good engineering practice is that the pump does not become the high point in the system).

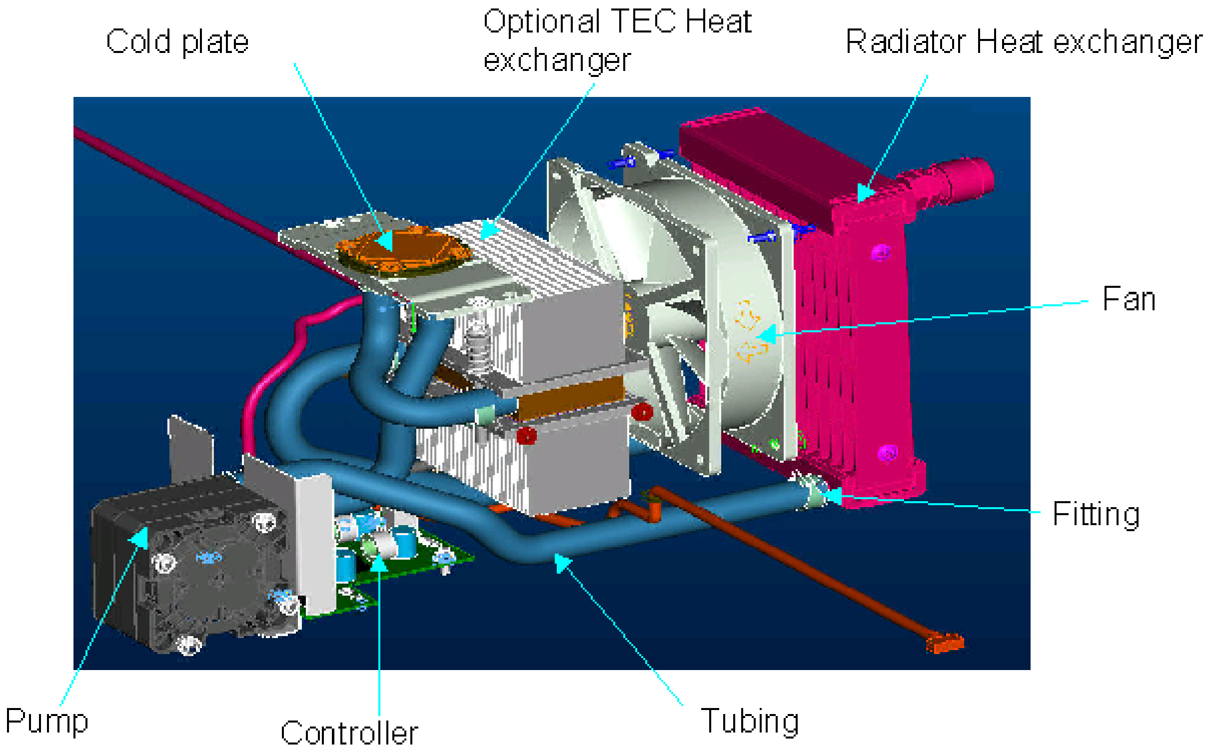
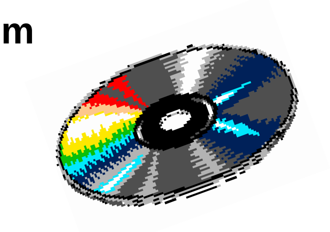


Figure 2: Liquid filled sealed heat sink system

Continued on Page 28

2004 / 2005 / 2006 / 2007 IEEE-PSE Symposium



CD Purchasing Information

SYMPOSIUM PAPERS ON CD:

The Product Safety Engineering Society continues to offer the 2004 IEEE PSES records for sale. The cost for the CD is $35 plus shipping and handling for IEEE members; $50 plus shipping and handling for non-IEEE members. At this time, check or money orders are the means for payment. Please provide the following information:

CDs to be shipped to- (Please print or type.)

Name:____

Mailing address::____

____

____

____

IEEE member number:__________________

Shipping and handling: $5 per CD

Payment: Check or money order.

Make Check or money order to: "IEEE Product Safety Society"

Quantity 2004:____ x $35 = _________ for IEEE members
Quantity 2004:____ x $50 = _________ for non-IEEE members
Quantity 2005:____ x $35 = _________ for IEEE members
Quantity 2005:____ x $50 = _________ for non-IEEE members
Quantity 2006:____ x $35 = _________ for IEEE members
Quantity 2006:____ x $50 = _________ for non-IEEE members
Quantity 2007:____ x $35 = _________ for IEEE members
Quantity 2007:____ x $50 = _________ for non-IEEE members

S&H: QTY_____ x $5 = _________

Total = _________

Send payment to:

IEEE Product Safety Engineering Society
c/o Richard Georgerian, PSES Board of Directors
7103 Sioux Court
Longmont, CO 80504
U.S.A.

Depending on stock availability allow 2 to 3 weeks for delivery.

Safeguards

In a refillable LFHS, a minimum of two safeguards must be provided to insure protection against leaks (if one fails, the other still provides protection). The basic safeguard is that under normal and abnormal operating conditions, the liquid does not leak. The supplementary safeguard is that the escaped liquid is contained in an area where there are no parts at hazardous voltage. If the basic safeguard fails, the location of the LFHS should be such that any escape of liquid is prevented from reaching any parts that may result in a hazard.

Alternatively, the liquid may be contained in a sealed containment system comprising a reinforced safeguard so that it is not expected that the liquid will leak. We already said above that a sealed system is preferred and therefore comprises a reinforced containment system and shall be tested as such.

The safety requirements described in this paper are for a reinforced (sealed) containment LFHS even though the same requirements may be applied to a refillable LFHS if tests are conducted on a system that has been subjected to a number of refilling operations expected during its life. The cap is an important component in this case and becomes part of the reinforced safeguard. The safety considerations for sealed LFHSs are based on the following:

-1 Located inside or outside the enclosure;

-2 Located adjacent to SELV circuits or parts at hazardous voltage;

-3 Located next to an open frame or enclosed power supply

Cooling liquids for an LFHS

The cooling liquid may be conductive, flammable, toxic, corrosive or may have physiological effects on the body. All such information is contained in the “Material Safety Data Sheets (MSDS)” for the cooling liquid. A conductive liquid may produce a shock hazard if it bridges an accessible conductive part to a part at hazardous voltage. A flammable liquid may ignite when subjected to heat or arcing. Toxic chemicals may cause injury to the body. For all such hazards presented by the cooling liquid, suitable safeguards need to be provided. An ideal liquid would be nonconductive, non-flammable, non-toxic, non-corrosive and has no other chemical hazards. The MSDS should be carefully studied to find out the possible effects of the chemical on the human body and instructional safeguards shall be included in the instructions to warn against the possible effects of the cooling liquid on the human body. An example of a partially conductive coolant is water; an example of a conductive coolant is mercury; an example of a flammable coolant is any petroleum based coolant or alcohol; and an example of a toxic coolant is an acid.

Almost all the coolants are brand named as they use a mixture of a particular coolant such as glycol (ethylene or propylene), silicone polymer mixed with lot of additives to make them non-corrosive or provide them the desired temperature range. Various manufacturers such as Dow Chemicals and Dynalene provide a wide variety of specially formulated liquid coolants. The coolant shall have high thermal conductivity, latent heat of evaporation and specific heat; high boiling point; high chemical and thermal stability; high flash point and auto-ignition temperature or preferably nonflammable; low viscosity; low freezing point and burst point; non-corrosive to materials of constructions; and environmentally friendly and non-toxic.

Note: For further information on coolants, see:

http://www.dynalene.com/

http://electronics-cooling.com/articles/2006/2006_may_a2.php

http://www.dow.com/heattrans/?WT.mc_id=DLT%20Google%20Coolants&WT.srch=1

Refillable and sealed LFHSs

Most commonly used LFHSs are sealed units made to last for the life of the equipment. While refillable LFHSs require periodic maintenance, they may pose additional problems due to the use of incorrect refilling liquid; the incorrect amount of liquid; liquid spillage during refilling; exposure of the body to the liquid; somebody trying to smoke near a flammable liquid; etc.

Operation

Figure 3 shows the liquid flow and the heat flow. The central processing unit (CPU) or the part that is required to be cooled is mounted on the cold plate. The heat from the CPU is transferred to the cold plate. A high reliability pump forces the liquid to flow in the system. The pump draws the hot liquid from the cold plate and sends this hot liquid to a liquid to air heat exchanger that works like a radiator in a car to remove most of the heat to the outside by increasing the exposed surface. Pump has a built in reservoir and volume compensator. A tachometer informs the controller about the pump speed. The tubing carries the cooled liquid to an optional but special thermoelectric cooling (TEC) heat exchanger to cool the liquid further. A fan draws air slightly above ambient from the radiator and throws this air at the special TEC heat exchanger unit. The liquid leaving the special TEC heat exchanger is virtually at ambient air temperature. The special TEC heat exchanger contains thermoelectric modules that use the Peltier effect to transfer heat from one ceramic face to another ceramic face and so on when a DC current is applied. This is similar to a car radiator where the coolant carries the heat away but here the electrons carry the heat away from one ceramic plate to another (TEC exchanger).

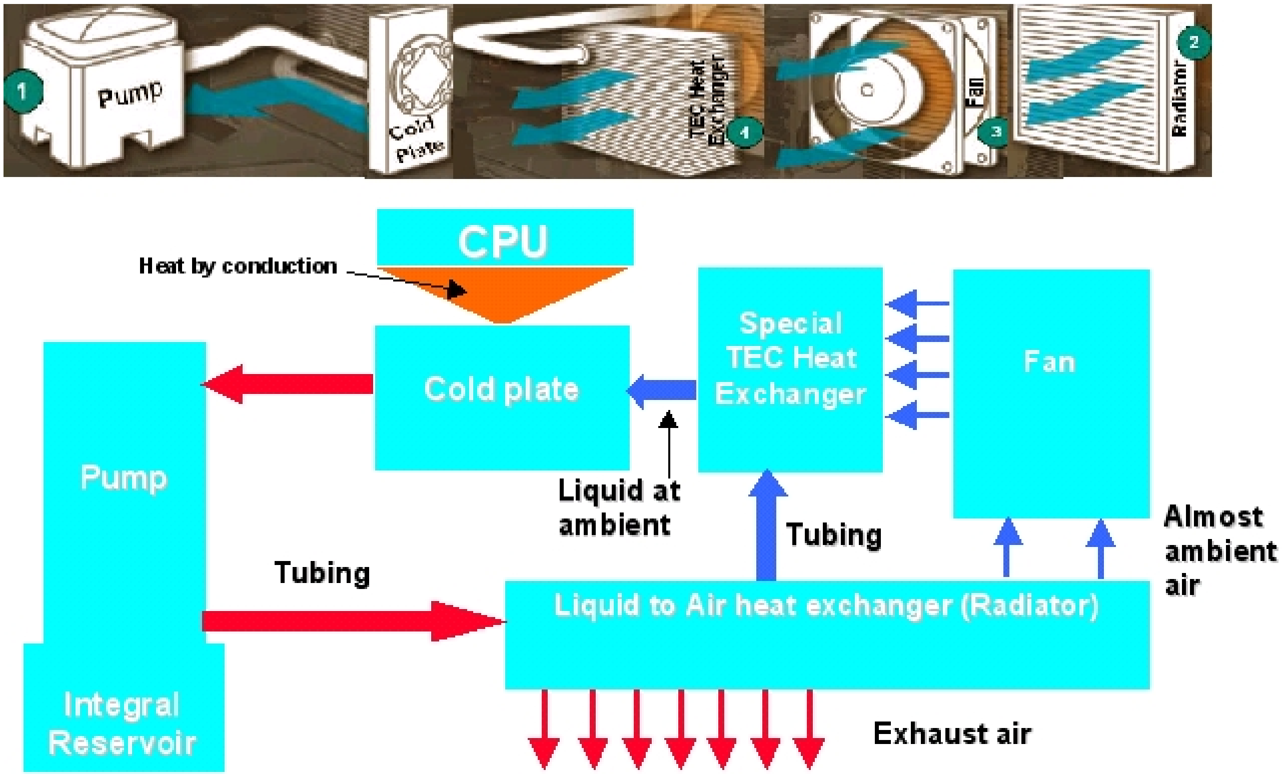


Figure 3: LFHS liquid flow and heat flow diagram

Continued on Page 30

The wider arrows show the liquid flow with red arrow carrying the heat in the direction of the arrow; and the blue arrow carrying the cold liquid in the direction of the arrow. The thinner arrows indicate the air flow with red arrow carrying the hot air in the direction of the arrow and the blue arrow carrying the cold air in the direction of the arrow.

Assumptions

Following assumptions are made (these assumptions apply to both sealed and refillable units except the last dash paragraph that applies only to refillable LFHS):

- The tubing is a single-layered metal (copper) construction. If tubing is nonmetallic then the flammability requirements of the applicable standard need to be taken into account (even though internal temperature of the tubing is same as the temperature of the cooling liquid, a flame due to another source in the product may ignite the tubing from inside or outside). Both metallic and nonmetallic may qualify as a reinforced safeguard if they pass the required tests. In addition, the nonmetallic tubing must be able to pass tensile strength requirements after conditioning tests to simulate aging. Under high pressure, the tubing may tend to expand or elongate.

- The fittings are metal. If nonmetallic then the flammability requirements of the applicable standard and creep resistance requirements need to be taken into account. These requirements apply independently of if the tubing is metallic or nonmetallic.

- Working pressure is determined under normal operating conditions and abnormal operating conditions. The hydrostatic test pressure is 5 times the working pressure under normal operating conditions, abnormal operating conditions and construction (tubing, fitting, heat exchanger, any joints, etc.) must be suitable for this working pressure and also at a certain minimum temperature which is taken as to be not less than 85 ^{o}C. Higher temperatures under normal, abnormal or single fault conditions would dictate a measurement of working pressure at that temperature.

- Working pressure is also determined under single fault conditions; the hydrostatic test pressure is three times the working pressure under single fault conditions.

- The fluid does not cause corrosion (corrosion may reduce the life of the LFHS) and is not flammable unless a reinforced containment is provided (e.g. corrosion resistant and nonflammable cooling liquid for example, propylene glycol). Corrosion may occur in a sealed system also as it may come from the outside (exposed parts of the radiator may get affected by corrosion from outside and therefore, appropriately coated material must be used to make the parts corrosion resistant over the life of the product). Manufacturers of coolants add special additives to make them corrosion resistant.

- The liquid is non toxic as proven by the MSDS for the fluid material unless a reinforced (sealed) containment is provided. Appropriate instructions for disposal at the end of life need to be provided.

- The LFHS is used inside the enclosure of the equipment. If the LFHS is used outside the enclosure then additional safety criteria (protection against mechanical handling, impact, etc.) needs to be considered.

- For refillable LFHSs, instructional safeguards are provided for proper refilling of the cooling liquid; precautions to be taken; how to insure that the LFHS cap has been properly closed; etc. The working pressure at the operating temperature is much higher and the reinforced safeguard must remain intact after the refilling operation is completed.

APPLICABLE STANDARDS (that need to be considered):

There was no single safety standard found that addressed the safety considerations for LFHSs. The following standards were consulted in whole or in part for the safety considerations for equipment using liquid filled heat sink systems.

- IEC/UL60950-1 (referred to further as 60950-1): Safety standard for IT equipment
- UL Subject 2178: Outline of Investigation for Marking and Coding Equipment: A part of this standard covers creep resistance of plastics and compatibility issues between a plastic material and a liquid and effect of liquids on tensile strength of plastic materials.
- UL 1995: Heating and cooling equipment: A part of this standard covers the evaluation of containers under pressure.
- IEC 61010-1: Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements: A part of this standard covers spillage of liquids from non-pressurized containers
- IEC 60065: Audio/video apparatus: A part of this standard covers the vibration test
- Miscellaneous Standards (used for test methods only, see Test Program for details)

Safety Testing Agencies may utilize additional standards and test methods to address the complete scope of potential hazards.

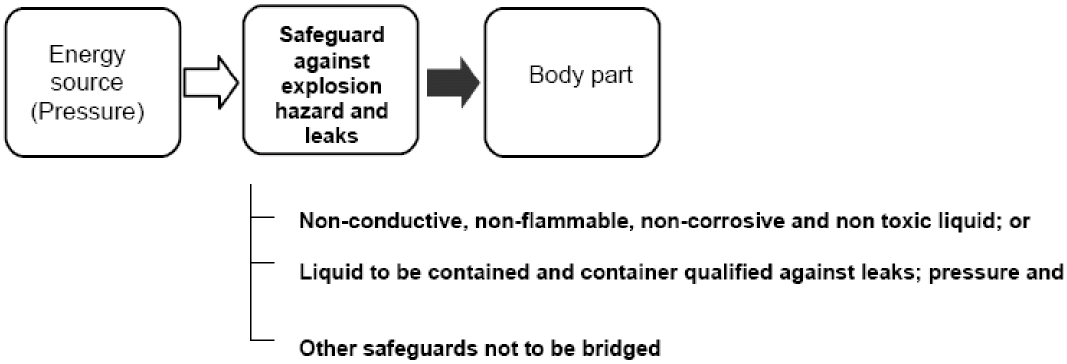
Possible hazards

This discussion only applies to a sealed LFHS. It can be applied to refillable systems after conducting a number of refilling operations and conducting all the tests after such operations as explained above. The safeguard is the containment system that should prevent leakage. If there is no leakage, then we don't care about the nature of the coolant except that the liquid shall not be corrosive to the material of the container (some liquids may corrode plastics also and therefore, compatibility of the materials must be established before they are used). Ammonia was a popular coolant, but due to leakage and consequent injury in early refrigeration systems, ammonia now is seldom used even in sealed systems. Likewise, chlorofluorocarbons were used in automobile air conditioners, but automobile systems could be damaged and the coolant released into the atmosphere could result in damage to the ozone layer.

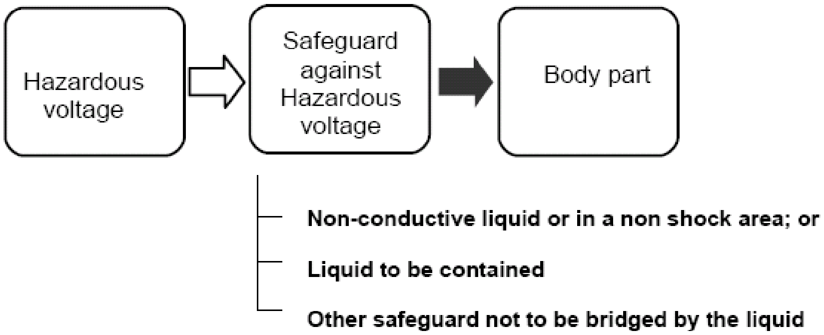
During the normal operating conditions, abnormal operating conditions and single fault conditions of the equipment, the temperature goes higher which results in an increase in the pressure in the LFHS. This increased pressure is the energy source that may cause the unit to explode if proper safeguards are not provided. This is known as boiling liquid expanding vapor explosion (BLEVE). Such an explosion occurs when a vessel containing pressurized liquid ruptures. The rupturing can occur due to corrosion or failure of the vessel under pressure. When rupture occurs, the vapor may leak rapidly and that drops the pressure at the point of leak which causes a violent boiling of the liquid. This results in a release of large amount of vapor. The pressure of this vapor is very high resulting in an explosion that may completely destroy the containment vessel. That is why it is so important to design and test the containment vessel as a reinforced safeguard. A liquid need not be flammable for the explosion to occur. If there is no pressure build up (such as in an open container), possibility of explosion is not likely. The ideal liquid used should be non-conductive; non-flammable; non-toxic; non-corrosive; or contained in a reinforced container immune to corrosion (the coolant and the container materials must be compatible with each other in terms of corrosion). The reinforced container must provide protection against build up of pressure and there shall be no leakage (reinforced safe-

Continued on Page 32

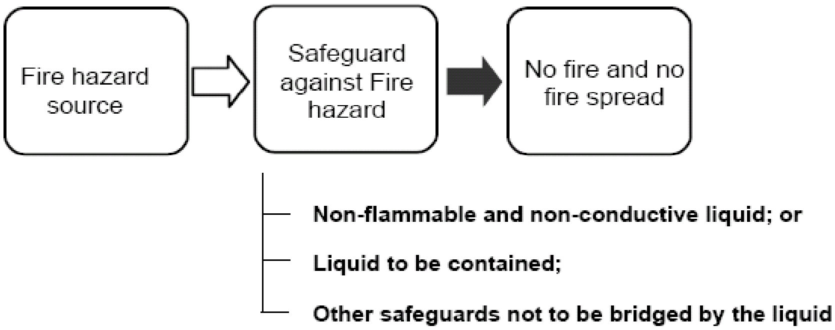
guard). The container needs to be qualified against any leaks as the leak may not repeat in the same place if the LFHS is permitted to leak (if the container is qualified as a basic safeguard only and additional supplementary safeguard is provided to contain the leaked material).



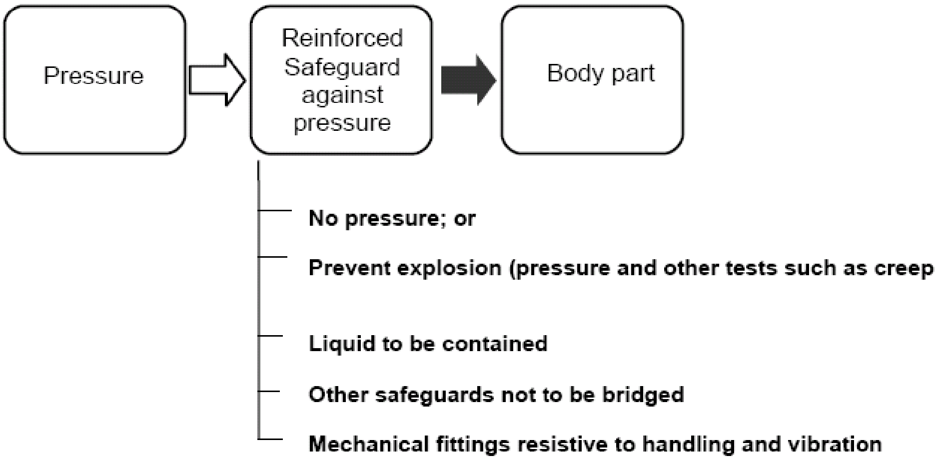
Electric shock hazard: The liquid must be non-conductive or must not bridge any safeguards (must be contained and must not leak as the bridging can be different each time if permitted to leak). From purely shock hazard point of view, it is okay for a non-conductive cooling liquid to leak and bridge safeguards that provide protection against electric shock.



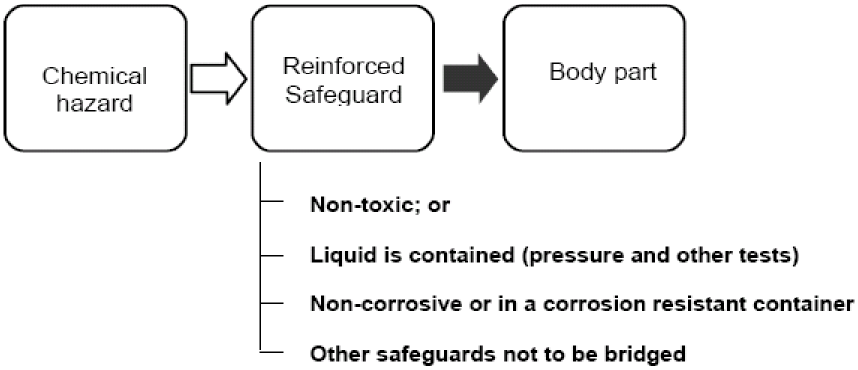
Fire hazard: The liquid must be non-flammable; non-conductive (bridging does not result in shorts that may create heat) or must not bridge any safeguards (must be contained and must not leak as the bridging can be different each time if the liquid is permitted to leak). From a fire hazard point of view, it is okay for a coolant to leak if the coolant is nonconductive and nonflammable.



Mechanical hazard: The build up of pressure in the system must not present an explosion hazard (criteria for pressure testing is usually five times the working pressure under normal operating conditions or three times the working pressure under abnormal or single fault conditions whichever is higher); the liquid must be non-conductive (conductive liquid may bridge electrical contact gaps that provide interlocked protection for doors or covers that provide safeguards against mechanical hazard) or must not bridge any safeguards (Must be contained and must not leak as the bridging can be different each time if liquid is permitted to leak). The handling of mechanical parts by ordinary and skilled persons and any vibrations, etc. should not make the fittings loose. A vibration test needs to be conducted to insure the fittings stay in place and do not result in any leakage.



Chemical hazard: The liquid must be non-toxic and non-corrosive or contained in a corrosion resistant container; (must be contained and must not leak as the bridging of other safeguards can be different each time if the liquid is permitted to leak).



Conditions of acceptability

Safety Testing Agencies may add conditions of acceptability (C of A) when they qualify LFHS as a component. Such C of A must be carefully considered when designing and evaluating the final product containing the LFHS.

Instructional safeguards

The following instructional safeguards need to be considered:

Continued on Page 34

The liquid filled heat sink system is not user-serviceable;

For a refillable LFHS, instructions, precautions and inspections that are necessary for the user to conduct the refilling operation (including the proper securement of the cap) as applicable. In addition, a warning marking to not open the cap when hot shall be provided.

The liquid filled heat sink cooling system is not refillable or replaceable (as appropriate);

User should be cautious when removing/inserting accessory cards and drives to avoid damaging any part of the system (i.e. causing a leak in the tubing) - assumes user accessibility;

User should be made aware that the system has fluid and any sign of fluid leakage should result in the user shutting down the system immediately and contacting manufacturer;

User should also be instructed on the hazards of eye or skin contact and proper cleaning methods (e.g. avoid contact with skin, use dry clean cloth);

The user should be warned that any modification to the system could result in electric shock, fire or other hazards;

Any other instructional safeguard as applicable.

Agencies may require additional instructional safeguards.

Test Program

After a review of the standards mentioned under “Applicable standards” above, the following tests listed under “Possible Test Program” should be considered when evaluating an LFHS. All specified conditions of acceptability by the safety testing agencies need to be taken into account. There may be a need for additional tests depending upon the location of the LFHS and its vicinity to other and type of components and use of any other features such as a refrigerating unit.

Note: It is assumed that all construction and test criteria of the applicable end product standard apply. The test program mentioned here only includes those end product tests that would be affected by the liquid filled heat sink system and does not represent a full product investigation.

Other possible considerations

Manufacturer may consider conducting the following additional tests for a sealed LFHS:

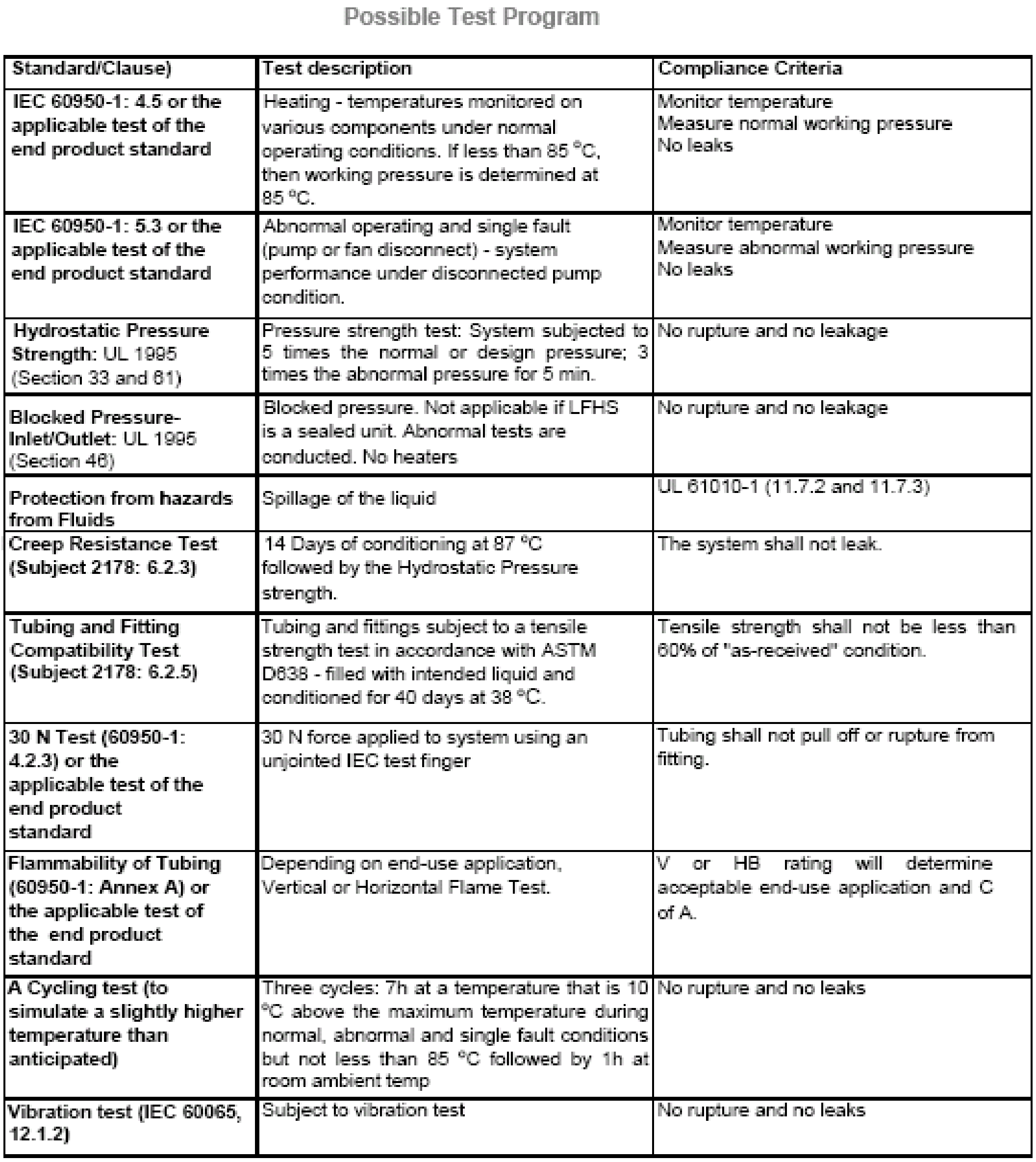
Coolant: Normally, for a reinforced safeguard in a sealed system, we do not expect any leakage, so one would expect that any coolant may be used. In practice, due to unforeseeable misuse or other factors, there is always a possibility of a leak (that is the biggest fear of a designer). Due to these reasons and concerns for safety of workers during production (such as filling the unit and sealing) and disposal concerns desire that a nontoxic, nonflammable, non-corrosive and nonconductive liquid should be used. Safety certification agencies may impose their own additional instructional safeguards based on the nature of the chemical used (see Instructional safeguards).

Life cycle test: This shall be conducted to simulate the expected life duration and at the end of this testing the LFHS must not fail in a way to cause damage to safeguards especially any leaks or corrosion (especially of the heat exchanger as the material is thinner in the heat exchanger area). Non-corrosive liquids reduce this possibility and lengthen the life of the LFHS.

Burst pressure test: The hydrostatic test as given below in the table should be continued beyond the maximum pressure required for the hydrostatic pressure test to know the pressure at which a leak occurs or the LFHS bursts open and insure that there is a sufficient margin from the maximum pressure required for the hydrostatic pressure test. The burst pressure should be about 15 to 20 times higher than the working pressure. That provides sufficient margin to put a safe product on the market.

Summary: A sealed LFHS shall be designed and tested to insure that under normal operating, abnormal operating and single fault conditions the LFHS does not become a safety hazard. The containment vessel should be designed and tested as a reinforced safeguard as a protection against excessive pressure that develops due to the hot liquid in the LFHS. Any leak in the LFHS may result in a hazardous situation and shall be avoided. The ideal liquid preferably should be non-flammable, non-toxic, non-corrosive and non-conductive. User should be provided with appropriate instructional safeguards in order to avoid any hazard that may result from the use of LFHS in the equipment.

Conclusion: The sealed LFHS is a preferred cooling system when compared to a refillable system and when designed and tested properly offers a better protection for the equipment in which it is used over the lifetime of the product.



Possible Test Program

Standard/Clause)	Test description	Compliance Criteria
IEC 60950-1: 4.5 or the applicable test of the end product standard	Heating - temperatures monitored on various components under normal operating conditions. If less than 85 °C, then working pressure is determined at 85 °C.	Monitor temperature Measure normal working pressure No leaks
IEC 60950-1: 5.3 or the applicable test of the end product standard	Abnormal operating and single fault (pump or fan disconnect) - system performance under disconnected pump condition.	Monitor temperature Measure abnormal working pressure No leaks
Hydrostatic Pressure Strength: UL 1995 (Section 33 and 61)	Pressure strength test: System subjected to 5 times the normal or design pressure; 3 times the abnormal pressure for 5 min.	No rupture and no leakage
Blocked Pressure-Inlet/Outlet: UL 1995 (Section 46)	Blocked pressure. Not applicable if LFHS is a sealed unit. Abnormal tests are conducted. No heaters	No rupture and no leakage
Protection from hazards from Fluids	Spillage of the liquid	UL 61010-1 (11.7.2 and 11.7.3)
Creep Resistance Test **(Subject 2178: 6.2.3)**	14 Days of conditioning at 87 °C followed by the Hydrostatic Pressure strength.	The system shall not leak.
Tubing and Fitting Compatibility Test (Subject 2178: 6.2.5)	Tubing and fittings subject to a tensile strength test in accordance with ASTM D638 - filled with intended liquid and conditioned for 40 days at 38 °C.	Tensile strength shall not be less than 60% of "as-received" condition.
30 N Test (60950-1: 4.2.3) or the applicable test of the end product standard	30 N force applied to system using an unjointed IEC test finger	Tubing shall not pull off or rupture from fitting.
Flammability of Tubing (60950-1: Annex A) or the applicable test of the end product standard	Depending on end-use application, Vertical or Horizontal Flame Test.	V or HB rating will determine acceptable end-use application and C of A.
A Cycling test (to simulate a slightly higher temperature than anticipated)	Three cycles: 7h at a temperature that is 10 °C above the maximum temperature during normal, abnormal and single fault conditions but not less than 85 °C followed by 1h at room ambient temp	No rupture and no leaks
Vibration test (IEC 60065, 12.1.2)	Subject to vibration test	No rupture and no leaks

Acknowledgement: The author wants to thank all of the Dell staff and others who provided comments especially Rich Nute who encouraged me to add appropriate rational and explanation of various safety considerations and was patient enough to provide comments to continuously make this a better article.

News and Notes

IEC 60038, *IEC standard voltages* being revised

IEC TC 8 is in the process of voting on a committee draft revision of the standard for supply voltages and preferred voltage ratings of mains-connected products. Voting will close 2008-04-25.

UL Continues Work on New Motor Standards

According to UL, "UL proposes the first edition of UL 1004-1, *Rotating Electrical Machines - General Requirements*. The proposed UL 1004-1 is the first standard in a series of standards. UL 1004-1 addresses the general requirements for all rotating machinery, and subsequent standards in the series will address the particular product requirements and will cover specific constructions, such as servo and stepper motors, generators, impedance protected motors, and so on.

"UL 1004 series is a consolidation and rewrite of UL 1004, 1004A, UL 1004B, and UL 2111. The rewrite and consolidation of the rotating machinery requirements is intended to result in Standards and requirements that are more reflective of current and emerging technologies such as brushless DC (BLDC) or electrically commutated motors (ECM), servo motors, stepper motors, and the like. In addition, this is intended to result in Standards that represent the most current technical philosophies. UL 1004, UL 1004A, UL 1004B, and UL 2111 will eventually be withdrawn after the new UL 1004-1 and series standards are published."

The first five proposed standards are:

§ UL 1004-1/UL2517, *Rotating Electrical Machines - General Requirements*

§ UL 1004-2/UL 2521, *Impedance Protected Motors*

§ UL 1004-3/UL 2519, *Thermally Protected Motors*

§ UL 1004-4/UL 2520, *Electric Generators* [generator heads]

§ UL 1004-5/UL2522, *Fire Pump Motors*

ASSE reaches out to students

The American Society of Safety Engineers, whose members manage, supervise and consult on safety, health, and environmental issues, is working to create interest in the occupation of safety engineer by sending its 63-page *Career Guide to the Safety Profession* to high school counselors across the U.S.

Contents of the guide include, "What is the Safety Profession?," "What Safety Professionals Do," "Where Safety Professionals Work," "Employment Outlook for Safety Professionals," "How to Become a Safety Professional," "Profiles of Safety Professionals," and "Resources." According to its Foreword, "The guide gives critical information needed in selecting the right undergraduate and graduate academic programs that meet the individual needs for entering a career in safety as well as continuous professional growth."

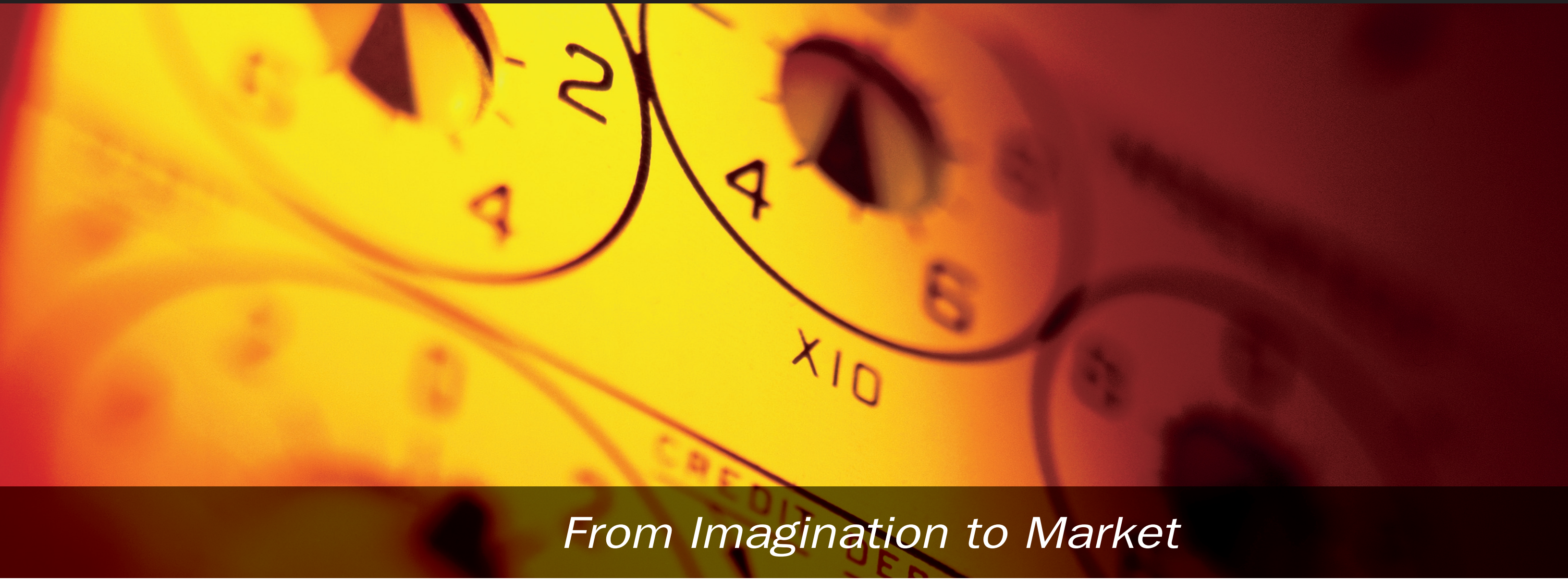
The *Career Guide* is offered online at www.asse.org/foundation under "publications."

ICPHSO to hold conference in Beijing

The International Consumer Product Health and Safety Organization (ICPHSO) will hold its International Consumer Product Safety Conference in Beijing May 21, 22, 2007. The conference will focus on the latest information on the development and enforcement of consumer product safety policies. For conference information visit www.icphso.org.

IEEE PSES BoD Election Results

Doug Nix and Peter Tarver as new members to the PSES Board of Directors. Jim Bacher and Mark Montrose returning members to the BoD of the society


From Imagination to Market

The Product Safety Engineering Newsletter is published quarterly during the last month of each calendar quarter. The following deadlines are necessary in order to meet that schedule.

Closing dates for submitted articles:

1Q issue: February 1
2Q issue: May 1
3Q issue: August 1
4Q issue: November 1

Closing dates for news items:

1Q issue: February 15
2Q issue: May 15
3Q issue: August 15
4Q issue: November 15

Closing dates for advertising:

1Q issue: February 15
2Q issue: May 15
3Q issue: August 15
4Q issue: November 15

Booked your trip to the 2008 Symposium on Compliance Engineering yet?

Institutional Listings

We invite applications for Institutional Listings from firms interested in the product safety field. An Institutional Listing recognizes contributions to support publication of the IEEE Product Safety Engineering Newsletter. To place ad with us, please see :

http://www.ieee.org/ieeemedia
Click here to go to the IEEE PSES advertising pdf

Tthe Product Safety Engineering Society will accept advertisements for employment and place looking for work ads on our web page. Please contact Dan Roman for details at dan.roman@ieee.org .

The
Product
Safety
Engineering
Newsletter

Gary Weidner
GW Technical Services Inc.
2175 Clarke Drive
Dubuque, IA 52001-4125

CHANGE SERVICE REQUESTED