POWER SUPPLY
and
PRINTER-SCANNER-COPIER-FAX
and
LCD TELEVISION
investigated to draft IEC 62368-1

T. SHIOTA AND T. KONDO

RICHARD NUTE

JAPAN QUALITY ASSURANCE
ORGANIZATION (JQA)

HB ENGINEERING EXPERT,
TC 108/HBSDT

OSAKA AND TOKYO, JAPAN

SAN DIEGO, CALIFORNIA, U.S.A.

Orange County Product Safety Engineering Society meeting, 23 March 2010
IEC 60950-1 versus IEC 62368-1

- IEC 60950-1
  - Incident-based
  - Product-specific
  - Construction based
  - Reactive

- IEC 62368-1
  - Hazard-based
  - Technology independent
  - Performance based
  - Proactive
INCIDENT BASED SAFETY ENGINEERING

- Incident happens
- Analyse incident
- Patch construction that avoids incident or mitigates undesired results
- Measure effectiveness
- Construction Effective?
  - no
  - yes

Standardise construction

Orange County Product Safety Engineering Society meeting, 23 March 2010
If there was no safety standard, how would you make a safe product?
The limit values for determining whether or not an energy source is hazardous are based on IEC Basic and Group safety publications.

The safeguard tests and parameters are based on IEC Basic and Group safety publications.
### IS THE SOURCE HAZARDOUS?

<table>
<thead>
<tr>
<th>Class 1 energy source</th>
<th>Class 2 energy source</th>
<th>Class 3 energy source</th>
</tr>
</thead>
<tbody>
<tr>
<td>May be detectable, but is not painful nor is it likely to cause an injury.</td>
<td>May be painful, but is not likely to cause an injury.</td>
<td>Capable of causing an injury.</td>
</tr>
<tr>
<td>Ignition not likely.</td>
<td>Ignition possible, but limited growth and spread of fire.</td>
<td>Ignition likely; rapid growth and spread of fire.</td>
</tr>
</tbody>
</table>
### EXAMPLES OF ENERGY SOURCES

<table>
<thead>
<tr>
<th></th>
<th>Class 1 energy source</th>
<th>Class 2 energy source</th>
<th>Class 3 energy source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric shock injury, energy source class ES-</td>
<td>&lt; 30 V rms or &lt; 0.5 mA</td>
<td>&lt; 50 V rms or &lt; 5 mA</td>
<td>&gt; 50 V rms and &gt; 5 mA</td>
</tr>
<tr>
<td>Electrically-caused fire, power source class PS-</td>
<td>&lt; 15 watts</td>
<td>&lt; 100 watts</td>
<td>&gt; 100 watts</td>
</tr>
<tr>
<td>Mechanical injury, energy source class MS-</td>
<td>&lt; 7 kg mass</td>
<td>&lt; 25 kg mass</td>
<td>&gt; 25 kg mass</td>
</tr>
<tr>
<td>Thermal injury, energy source class TS-</td>
<td>&lt; 48 °C</td>
<td>&lt; 58 °C</td>
<td>&gt; 58 °C</td>
</tr>
</tbody>
</table>
LCD TELEVISION OVERVIEW
1. Identify the ES1, ES2 and ES3 parts and circuits and their respective safeguards.

2. Identify the PS1, PS2, and PS3 circuits and the fire safeguard methods.

3. Identify the MS1, MS2, and MS3 parts and circuits and their respective safeguards.

4. Identify the TS1, TS2, and TS3 parts and circuits and their respective safeguards.
THREE-BLOCK MODEL FOR ELECTRICALLY-CAUSED INJURY

Hazardous energy source

Transfer mechanism

Body

ES3 (> 50 V and > 5 mA)

Two electrical connections (assume one earth connection)

Body impedance
ES CLASS IS BOTH VOLTAGE AND CURRENT
PRODUCT INVESTIGATION: ELECTRIC SHOCK

- What are the ES1, ES2, and ES3 parts and circuits?

<table>
<thead>
<tr>
<th>Electric shock injury, energy source class ES-</th>
<th>ES-1</th>
<th>ES-2</th>
<th>ES-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES-1</td>
<td>&lt; 30 V rms or &lt; 0.5 mA</td>
<td>&lt; 50 V rms or &lt; 5 mA</td>
<td>&gt; 50 V rms and &gt; 5 mA</td>
</tr>
</tbody>
</table>

- What are the product safeguards against electric shock?

<table>
<thead>
<tr>
<th>Electric shock injury, energy source class ES-</th>
<th>ES-1</th>
<th>ES-2</th>
<th>ES-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES-1</td>
<td>None</td>
<td>Basic insulation</td>
<td>Double or reinforced insulation</td>
</tr>
</tbody>
</table>
reinforced insulation between ES3 (mains conductors) and ES1 (accessible parts)
ES1 and ES3
CIRCUIT IDENTIFICATION

- ES-3
  - (mains circuits)
  - mains isolating transformer
  - Basic or reinforced insulation

- ES-1
  - (earthed parts and secondary circuits)
  - Opto-isolator
  - Y-cap

- Y-cap

Orange County Product Safety Engineering Society meeting, 23 March 2010
VARIOUS INSULATIONS

- AC input
- DC output
- Insulation (sheet insulator)
- Earthing (steel enclosure)
- Insulation (clearances and creepage distances)
CLASS I SAFEGUARDS:
BASIC INSULATION AND EARTHING

BASIC INSULATION
Insulating sheet between mains conductors on bottom of board and chassis

EARTHING
(top cover and chassis bonded to PE terminal)

BASIC INSULATION
Insulating sheet between mains parts and inside top cover

BASIC INSULATION
Clearances and creepage distances between mains conductors and chassis
CLASS II SAFEGUARDS: DOUBLE INSULATION

BASIC INSULATION
Air (clearance) between mains terminals (ES3) and sheet insulation inside top cover

DOUBLE INSULATION
Between ES1 wires (earth and secondary) and mains circuits (ES3)

SUPPLEMENTARY INSULATION
Solid (sheet) insulation between air (clearance) and inside top cover (ES1)
CLASS II SAFEGUARDS: REINFORCED INSULATION

REINFORCED INSULATION
Solid (sheet) insulation between mains terminals (ES3) and inside of top cover (ES1)

REINFORCED INSULATION
Sheet insulation between printed wiring (ES3) and inside of enclosure (ES1)
PRODUCT INVESTIGATION:
ELECTRIC SHOCK

- What are the ES1, ES2, and ES3 parts and circuits?

<table>
<thead>
<tr>
<th>Electric shock injury, energy source class ES-</th>
<th>ES-1</th>
<th>ES-2</th>
<th>ES-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES-1 &lt; 30 V rms or &lt; 0.5 mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES-2 &lt; 50 V rms or &lt; 5 mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES-3 &gt; 50 V rms and &gt; 5 mA</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- What are the product safeguards against electric shock?

<table>
<thead>
<tr>
<th>Electric shock injury, energy source class ES-</th>
<th>ES-1</th>
<th>ES-2</th>
<th>ES-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES-1 None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES-2 Basic insulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES-3 Double or reinforced insulation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ES1, ES2, and ES3 parts

ES1 (USB)

ES2 (telephone)

ES3 (mains input)
ES1, ES2, and ES3 parts
ES1, ES2, and ES3 parts
NESGUARD BLOCK DIAGRAM

**Energy Source** | **ES1** | **ES2** | **ES3**
--- | --- | --- | ---
1 kHz up to 100 kHz |
Voltage | 30 V r.m.s. + 0.4 x f | 50 V r.m.s. + 0.9 x f | Greater than ES2 limit
Current | 0.5 mA r.m.s. x f | 5 mA r.m.s. + 0.5 x f |

f is in kHz.

**Allowed:**
- Voltage: $30 + 0.4 \times 35 = 44$ V r.m.s.
- Current: $0.5 \times 35 = 17.5$ mA

**Circuit:**
- 600 V
- 15 mA

Orange County Product Safety Engineering Society meeting, 23 March 2010
SAFEGUARDS AGAINST ES3

- Reinforced insulation (Between ES3 and ES1)
- Reinforced creepage and clearance (Between ES3 and ES1)
- Functional earthing (Sleeved earthing wire between ES1 and ES3)
SAFEGUARDS AGAINST ES2

Solid insulation behind board
Air insulation between board and barrier (enclosure)
(Between ES2 and ES1)

Creepage and clearance
(Between ES2 and ES1)
LCD TELEVISION – inside views

Output of inverter circuit (backlight): ES1

Power supply board: ES3
LCD TV -- Power supply board

Orange County Product Safety Engineering Society meeting, 23 March 2010
LCD TV: Power supply board -- bottom side

Outside of enclosure: ES1

Enclosure
Inside of transformer

- **ES3** primary wire
- **ES1** secondary wire
- Double insulation
- **ES3** primary wire
- Barrier

Safeguard between **ES3** and **ES1**
Operating voltage: 240V rms

Operating voltage: 300V rms

Operating voltage: 200V rms

Operating voltage: 24V rms max.
THREE-BLOCK MODEL FOR ELECTRICALLY-CAUSED FIRE

Hazardous energy source

Transfer mechanism

Heating of fuel material

Electrical energy conversion to thermal energy (watts)

Conduction
Convection
Radiation (Joules/second)

Material exceeds ignition temperature (Joules absorbed)
ELECTRICAL HEATING IS A FUNCTION OF BOTH POWER DISSIPATION AND TIME

Power

500 W
100 W
15 W

Time
3 s 5 s

PS 1 circuit
PS 2 circuit
PS 3 circuit

Orange County Product Safety Engineering Society meeting, 23 March 2010
PRODUCT INVESTIGATION: FIRE

What are the PS1, PS2, and PS3 circuits?

<table>
<thead>
<tr>
<th>Electrically-caused fire, power source class PS-</th>
<th>PS1 &lt; 15 watts</th>
<th>PS2 &lt; 100 watts</th>
<th>PS3 &gt; 100 watts</th>
</tr>
</thead>
</table>

What are the product safeguards against fire?

<table>
<thead>
<tr>
<th>Electrically-caused fire, power source class PS-</th>
<th>None</th>
<th>Keep out volume</th>
<th>Fire enclosure</th>
</tr>
</thead>
</table>
Output Characteristics
Rated 18 Volts, 2.3 Amperes

- Output power
- Output voltage
- Output current

Load resistance, ohms
Output voltage, Volts
Output current, Amperes
Output power, Watts

Determining PS1, PS2, or PS3

Orange County Product Safety Engineering Society meeting, 23 March 2010
PS1, PS2, and PS3 circuits

PS3 (telephone)

PS3 (mains)

PS2 (secondary circuits)
PS1, PS2, and PS3 circuits
FIRE SAFEGUARDS

Ignition Prevention Safeguards (applicable to PS2 circuits)
- Fault condition testing to determine if ignition will occur
- Distances from potential ignition source (PIS) to ignitable materials

Spread of Fire Safeguards (applicable to PS2 and PS3)
- Flame-retardant material
- Fire-containing enclosure
SAFEGUARDS AGAINST PS3

Fire enclosure
(encloses mains)
1 Flame-retardant molded plastic
2 Flame-retardant sheet
3 Metal

Fire enclosure
(encloses telephone circuits)
Flame-retardant sheet
Ignition Prevention Safeguards (applicable to PS2 circuits)

- Fault condition testing to determine if ignition will occur
- Distances from potential ignition source (PIS) to ignitable materials
**POTENTIAL IGNITION SOURCES (PIS)**

**Arcing PIS**
where an arc may occur due to the opening of a conductor or a contact
- $> 50 \, V_{\text{peak}} \, \text{a.c. or d.c.}$, and
- $> 15 \, (V_{\text{peak}} \times I_{\text{rms}})$

**Resistive PIS**
where power may be dissipated in a resistance
- $> 100 \, \text{W during first 30 seconds}$
- $> 15 \, \text{W afterwards}$
CANDIDATE PIS DEVICES IN PS2 CIRCUITS

Candidate Potential Ignition Source devices

Fire enclosures (connector housing is flame-retardant)
PIS WITH FLAME CONE AND ADJACENT PARTS - 1

Metal chassis

Plastic enclosure
Metal chassis

Plastic enclosure

Non-flame-retardant material

PIS WITH FLAME CONE AND ADJACENT PARTS - 2
LCD TELEVISION
PS1, PS2, and PS3 circuit identification

PS1
PS2
PS3
Prevent ignition

Fault condition test and separation from PIS
Prevent spread of fire

Fire enclosure required
THREE-BLOCK MODEL FOR MECHANICAL INJURY

Hazardous energy source

Transfer mechanism

Body part

- Electrical or potential energy conversion to kinetic energy
- Collision with body part
- Energy exceeds body susceptibility (Joule/area/second)
**PRODUCT INVESTIGATION – MECHANICAL INJURY**

## What are the MS1, MS2, and MS3 parts?

<table>
<thead>
<tr>
<th>Mechanical injury, energy source class MS-</th>
<th>MS1</th>
<th>MS2</th>
<th>MS3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS1</td>
<td>&lt; 7 kg mass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS2</td>
<td>&lt; 25 kg mass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS3</td>
<td>&gt; 25 kg mass</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## What are the product safeguards against mechanical injury?

<table>
<thead>
<tr>
<th>Mechanical injury, energy source class MS-</th>
<th>None</th>
<th>No overbalance</th>
<th>Floor-standing or fastened in place</th>
</tr>
</thead>
</table>
MS1 PARTS -- EXAMPLE
MS1, MS2, MS3
PART IDENTIFICATION

MS1 (rotating gear)

MS1 (moving carriage)

MS1 (moving carriage)
PART IDENTIFICATION

No moving parts → MS1

Mass: >25Kg

MS3
Three-Block Model for Thermal Injury

Hazardous energy source

Transfer mechanism

Body part

Thermal energy
(temperature, mass, thermal resistance, specific heat)

Conduction (touch)
(Joules/second)

Skin exceeds 48 C
(Joules absorbed)
MATERIAL TEMPERATURE AND CONTACT TIME

Orange County Product Safety Engineering Society meeting, 23 March 2010
### Product Investigation – Thermal Injury

#### What are the TS1, TS2, and TS3 parts?

<table>
<thead>
<tr>
<th>Thermal injury, energy source class TS-</th>
<th>&lt; 48 °C</th>
<th>&lt; 58 °C</th>
<th>&gt; 58 °C</th>
</tr>
</thead>
</table>

#### What are the product safeguards against thermal injury?

<table>
<thead>
<tr>
<th>Thermal injury, energy source class TS-</th>
<th>None</th>
<th>Warning (Instructional safeguard)</th>
<th>Not accessible (Equipment safeguard)</th>
</tr>
</thead>
</table>
EXAMPLE OF THERMAL INJURY and THERMAL SAFEGUARD

- Power converted to thermal energy
- Conduction
- Body part

- Power converted to thermal energy
- Safeguard
- Body part
TS1, TS2, TS3
PART IDENTIFICATION

Transformer: 91ºC
Heatsink: 95ºC

TS2
Transformer: 75ºC

TS3
Heatsink: 95ºC

TS3
Outside of enclosure: 36°C max

TS1, TS2, TS3
PART IDENTIFICATION
power supply
and
printer-scanner-copier-fax
and
LCD television

Richard Nute
H.B. Engineering Expert,
TC 108/HB/SDT
San Diego, California, U.S.A.

T. Shiota and T. Kondo
Japan Quality Assurance Organization (JQA)
Osaka and Tokyo, Japan