LOG OF MEETING

DIRECTORATE FOR ENGINEERING SCIENCES

SUBJECT: Meeting with Underwriter's Laboratories Thermoplastics Ad Hoc Committee.

DATE(S) OF MEETING: October 28, 1997

PLACE: UL Offices, Research Triangle Park, NC

LOG ENTRY SOURCE: Hammad Ahmad Malik

DATE OF ENTRY: October 30, 1997

COMMISSION ATTENDEES: Hammad Malik, ESEE

NON COMMISSION ATTENDEES:

Steve Giannoni (UL, Melville)
Rinus de Vos (DSM, Netherlands)
Inder Wadehra (IBM, Research Triangle Park)
Debbie Oates (UL, Northbrook)
Larry Bruno (UL, Northbrook)
Bob Davidson (UL, Melville)
Richard Nute (Hewlett-Packard, San Diego)
Wayne Morris (AHAM)
Bob Dellavalle (UL, Melville)
Al Brazauski (UL, Santa Clara)
Tim Kettiring (Geon)
Doug Wetzig (Geon)
Pat Toner (Society of the Plastics Industry)
Paul Brown (GE-Plastics)
Maggie Carroll (UL, Santa Clara)

SUMMARY OF MEETING: Mr. Larry Bruno provided opening remarks and then all attendees introduced themselves. The first item on the agenda (attached) followed.

Mr. Rich Nute provided an overview of ignition, combustion processes, heat transfer, and fire dynamics. Mr. Nute showed a video produced by the National Fire Protection Association on the ignition process and fire behavior. A video of an electrically caused fire on a printed circuit board was shown. This circuit board had five diodes in series and a 4 amp 20 volt power supply. Mr. Nute ended his presentation with overheads explaining some basic heat transfer principles.

Mr. Bob Davidson followed with an explanation of the Hazard Based Safety Engineering (HBSE) approach and went over a fire tutorial he authored (attached). The HBSE was described to be similar to an event tree. This tree linked several events in a causal relationship with the final outcome being an electrical appliance fire.

Mr. Steve Giannoni then presented a simple computer model utilizing finite element analysis to simulate heat transfer on a uniform flat surface. This model was presented to demonstrate that the principles of finite element analysis could be applied to modeling the behavior of thermoplastic enclosures of electrical products under fire conditions initiated by an internal failure.

Finally, Mr. Hammad Malik gave a brief presentation on the nature and current status of the CPSC thermoplastics project. This presentation generated considerable discussion and questions. The majority of meeting participants had questions as to the testing procedure being implemented as part of the project and the objectives of the testing. It was clearly explained that the project involved taking specimens of thermoplastic enclosures from actual end products. It was also explained that these specimens would then be conditioned and testing in accordance with UL enclosure flammability test (UL 94) and end-product flame tests (UL 746C). Lastly, the objective of testing was explained to include checking the flammability of the enclosures versus behavior of various plastics. The ultimate outcome of the project was clearly stated as determining the most appropriate means of addressing the problem of the contribution thermoplastic enclosures make to the spread of fire and making appropriate recommendations to change the relevant UL standards. Mr. Wayne Morris was extremely vocal in his opposition to the project and reiterated his concerns with the process by which CPSC makes recommendations to UL. Mr. Paul Brown restated the UL contention that the thermoplastics flammability issue would be best addressed on an end-product standard by standard basis.

On the whole the majority of the participants reacted positively to the work CPSC is undertaking and exhibited a willingness to cooperate with CPSC to reach the common objective of preventing electrical appliance fires from spreading beyond the appliance.

Melville - October 3, 1997
SU2181

To:
Ken Adams (SPI)
Paul Brown (GE Plastics)
Steve Giannoni (UL Melville)
Wayne Morris (AHAM)
Debbie Oates (UL Northbrook)
Hammad Malik(CPSC)
Doug Wetzig (GEON)
Al Brazauski (UL Santa Clara)
Bob Davidson (UL Melville)
Lou Mecseri (EIA/Sony)
Richard Nute (Hewlett-Packard)
Don Talka (UL Melville)
Inder Wadehra (IBM)

Subject: UL Plastics Flammability Ad Hoc Meeting Agenda

A meeting of the UL Plastics Flammability Ad Hoc will be held on October 28, 1997, at 9:30 am at UL's Research Triangle Park Facility. The following agenda items will be discussed at the meeting:

1. **Heating, Ignition and Combustion Processes of Plastic Materials:**
Rich Nute will present an overview of this topic. Included will be discussions on; the electrical ignition processes, prevention of ignition and fire containment. A videotape developed by the NFPA on this subject will also be shown.

   Follow this presentation Bob Davidson will discuss his first draft of a related document entitled "Fire Tutorial" (copy attached).

2. **Obtaining Additional CPSC Report Information:**
George Fechtmann will report on efforts to coordinate additional CPSC case studies with HBSE approach to plastics flammability. This would be the foundation for development of the HBSE guideline document for fire hazards.

3. **Computer Model to Study Energy Transfer:**
Steve Giannoni will report on the development of a research project proposal for a computer modeled study of energy transfer.

Regards:

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FIRST DRAFT

Fire Tutorial

Potential for fire-

In order for the potential for fire to exist, there needs to be present a combustible material (fuel), an oxidizing agent (typically atmospheric oxygen), and an ignition energy source (energy source capable of igniting the combustible material). The lack of any of these ingredients will preclude the potential for fire.

Ignition- (the initiation of flaming combustion)

In order for a combustible material to be ignited or support flame spread, it must be heated to its piloted ignition temperature. This requires an energy source capable of igniting the material (ignition energy source), an oxidizing agent, and exposure of the combustible material to the source (coupling combustible material to ignition source).

In electrotechnical equipment, the initial ignition energy source is generally in the form of electrical energy (although chemical energy and mechanical energy may also be ignition energy sources.) Once ignition occurs, the ignited material may be an ignition energy source for other combustible materials. In the case of solid combustible materials, the following is necessary in order for ignition to occur.

a. The presence of an electrical (or other) energy source of sufficient capacity to ignite combustible materials; and
b. Conversion of the electrical (or other) energy source to a thermal energy source (typically by way of resistance heating and/or arc heating) at a rate and for a duration sufficient to be capable of causing ignition: and
c. A heat transfer (conduction, convection, radiation) from the thermal energy source to the combustible material at a rate and for a duration sufficient to elevate the temperature of the combustible material to its pilot ignition temperature.

Sustained combustion-

Subsequent burning of a combustible material is governed by a continued supply of heat and oxidant to the pyrolyzing or vaporizing combustible. Consequently, burning will continue until:

a. The combustible material is consumed; or
b. The oxidizing agent concentration is lowered to below the concentration necessary to support combustion; or
c. Sufficient heat is removed or prevented from reaching the combustible material to prevent further fuel pyrolysis; or
d. The flames are chemically inhibited or sufficiently cooled to prevent further reaction.

Protection against fire-

Since ignition and sustained combustion are both required to result in destructive fire, fire safety can be achieved by either preventing ignition, or mitigating the consequences of ignition. However, since it may not be possible to achieve perfection in completely preventing the possibility of ignition or in completely mitigating the consequences of ignition, in practice fire safety is generally achieved by a combination of both approaches. The greater the likelihood of ignition, the greater the need to mitigate the consequences of ignition. The greater the severity of the consequences of ignition, the greater the need to reduce the likelihood of ignition. These concepts are illustrated in the attached fault model.

Protection against fire- preventing ignition

The prevention of ignition can be achieved by

a. Eliminating the potential for ignition by using electrical (and other) energy sources that do not have the capability of (i.e., potential for) igniting fuel; or
b. Controlling the rate and/or duration of conversion of electrical (and other) energy to thermal energy to levels not capable of igniting materials; or
c. Controlling the interaction between thermal energy ignition sources and fuel by (i) providing separation or barriers that prevent fuel or thermal energy sources from moving to a location where ignition can result and (ii) controlling the rate at which fuel receives heat by controlling the heat transfer mechanisms (conduction, convection, and radiation) such that ignition cannot result; or
d. Eliminating fuel; or
e. Controlling fuel ignitibility (controlling fuel properties or fuel environment)

(a) Eliminating ignition energy sources

Preventive measure (a), which involves eliminating the potential for ignition by eliminating potential ignition energy sources, necessitates the need for defining the minimum energy parameters that are required for there to be a potential for ignition. Since such parameters are directly related to the susceptibility of the fuel to ignition (fuel ignitibility) care must be taken with respect to assumptions concerning the ignitibility of materials likely to be encountered within electrotechnical equipment or its environment.

In the extreme case where there is a significant possibility that equipment will involve the use of, or being used in locations where there may be, flammable vapor/air mixtures, the need to identify a minimum ignition energy is particularly significant. For example, electrotechnical equipment or apparatus intended for use in locations where there is a risk of a flammable atmosphere being formed (i.e., "hazardous locations") needs to be designed in such a way that even the worst fault condition is not capable of igniting a stoichiometric mixture of a specific gas in air. Such equipment is sometimes referred to as "intrinsically safe" due to that fact that the electrical energy (and other energy forms) available in the equipment is incapable of ignition. In the case of electrical energy, electrical circuits are referred to as "intrinsically safe circuits" if the electrical energy is incapable of igniting a flammable atmosphere. Such circuits involve extremely conservative electrical energy related parameters (voltage, current, stored charge, electrical resistance, capacitance and inductance).

In the case of most electrotechnical equipment, however, fuel is normally in the form of solid polymeric materials that require substantially more energy (heat) to convert the solid into volatile vapors than the energy required to ignite liquids and gases that are flammable at normal ambient temperatures. As a practical matter, codes and standards covering electrotechnical equipment have established electrical energy criteria where the likelihood of igniting materials normally used in such equipment is considered low. Examples are Class 2 power sources and circuits where power is limited (e.g., max 15 watt circuits). It is important to note, however, that such circuits are not necessarily safe for all applications (i.e.,"intrinsically safe"), but only for those where the assumptions concerning the characteristics of fuels likely to be present or used are valid.

(b) Preventing ignition by controlling energy conversion

Ignition prevention measure (b) involves controlling the rate and/or duration of conversion of electrical (and other) energy to thermal energy to levels not capable of igniting materials.

In the case of electrotechncial equipment where the electrical (or other) energy source(s) is considered to be a potential ignition source, in order for such sources to actually become ignition sources the energy must be converted to thermal energy capable of igniting materials.

In order for an electrical energy source to ignite material, it must first be converted into thermal energy sufficient to cause the material to reach its pilot ignition temperature. An exception is flammable vapor/air mixtures which can be ignited by a weak electrical spark or arc capable of raising the mixture by only a few tens of degrees.

The principle heating mechanisms are resistance heating (a.k.a. Joule heating or I^2R heating) and arc heating. Dielectric heating and induction heating are also possible. Although electrical heating is always produced in the generation, distribution, control and utilization of electrical energy, excessive heating can occur as a result of abnormally high current, resistance, or abnormal arcing in electrical circuits due to poor electrical connections, use of conductors of insufficient ampacity, overloads, short-circuits and ground faults.

(c) Preventing ignition by controlling fuel-ignition source interactions

If thermal energy sources capable of igniting combustible materials are present, ignition can be prevented by controlling the interaction between the thermal energy source and fuel.

In the case of electrotechnical equipment in which thermal energy capable of igniting combustible material is a normal consequence of the function of the product (e.g., the thermal energy developed in electrical heating equipment), controlling the interaction between the thermal energy ignition source and polymeric materials is the principle ignition prevention measure. This is generally achieved by designing electrotechncial equipment with physical separation, barriers, and/or non-combustible insulating materials between the ignition source and the combustible material. The purpose of these is to prevent ignition by controlling the relative positions of the ignition source and polymeric material, or by controlling the heat transfer processes (conduction, convection and radiation) between the ignition source and polymeric material.

(d) Preventing ignition by eliminating fuel

Since ignition and subsequent burning cannot occur without the presence of a combustible material (fuel), elimination of fuel eliminates the potential for ignition and subsequent burning within electrotechnical equipment. However, since polymeric materials are needed to perform many necessary functions in electrotechnical equipment, total elimination of polymeric material is not a viable, practical option.

(e) Preventing ignition by controlling fuel ignitibility (controlling fuel properties or fuel environment)

In electrotechnical equipment where thermal energy ignition sources are present under normal operating conditions, or may be present under abnormal or fault conditions, the likelihood of ignition may be reduced by controlling the properties of the fuel (fuel ignitibility) or the fuel environment (e.g., controlling the availability of oxidant).

In electrotechnical applications where polymeric material is directly applied to electrical conductors in circuits having the capability of igniting combustible material (e.g., electrical insulation on line voltage conductors), or where the polymeric material serves to house such conductors (e.g., a polymeric enclosure), the likelihood of ignition of the material may be reduced by using materials that are resistant to ignition. The ignitibility of a polymeric material may depend upon a number of factors, including but not limited to the physical and chemical properties of the material, and the properties of the material environment.

Protection against fire- controlling combustion

If ignition occurs in electrotechnical equipment, protection against fire will depend upon mitigating the consequences of ignition. The consequences of ignition will depend on the degree to which it is possible to limit or control the subsequent combustion process within electrotechnical equipment. As indicated previously, the combustion process following an ignition event is governed by a continued supply of heat and oxidant to the pyrolyzing or vaporizing combustible. Consequently, the combustion process may be controlled by:

a. Limiting the availability (amount) of combustible material; or
b. Limiting the availability (amount) of oxidizing agent (typically oxygen); or
c. Limiting the amount of heat that can reach the combustible material to prevent continued fuel pyrolysis; or
d. Controlling fuel flammability (physical and chemical properties of the fuel- use of "flame retardant" materials)

(a) Controlling combustion by limiting availability of combustible material

Since continued burning (combustion) requires a continued supply of combustible material, the consequences of an ignition event can be mitigated by limiting the quantity of the material initially ignited, and by isolating the initially ignited material from other combustible materials to prevent the former from becoming an ignition source for the latter (i.e., preventing flame spread)

(b) Controlling combustion by limiting availability of oxygen

If the supply of air (which is approx 21 % oxygen) is unlimited, the rate of burning is said to be "fuel regulated". The nature of the fuel supply is then the most critical factor controlling the rate of combustion and spread of fire. If the supply of oxygen is limited, the rate of burning decreases and the fire is said to be "oxygen regulated". Normally, a fire will not continue to burn in oxygen concentrations of less than 15%. Given that a continued supply of oxygen in sufficient quantity is need to sustain combustion, combustion can be controlled by limiting the availability of oxygen.

(c) Control combustion by limiting heat transfer required for continued fuel pyrolysis

The three methods of heat transfer are conduction, convection, and radiation.
Although it is likely that all three heat transfer mechanisms contribute in every fire, frequently one dominates at a given stage of a fire or at a given location. For example, since conduction determines the rate of heat flow in and through solids, it plays an important role with respect to ignition and spread of flame over combustible solids. Convective heat transfer, which is the transfer of heat between a liquid or gas and a solid by fluid movement, occurs in all stages of a fire but is particularly important in the early stages where heat transfer by radiation may be low. Radiation heat transfer, which is proportional to the fourth power of temperature, is extremely important as the fire progresses and temperatures of the fuels, gases, and flames themselves are high.

Most polymeric materials, even those with flame retardants or inhibitors, can be made to continue to burn if continually exposed to a sufficiently intense external (i.e., external to the part itself) heat source. Examples are (1) heat transfer from other polymeric parts that may be burning or (2) non-combustion heat transfer from other thermal energy sources (which may or may not include the original ignition energy source).

On the other hand, continued burning of a polymeric material may be the result of heat feedback from the burning part itself. The combustion of a polymeric material is considered "self sustaining" if it continues to burn after removal of all external heat sources. This can occur if the heat generated by the oxidation of the fuel itself is fed back to the fuel and overcomes any heat losses so that continued vaporization and ignition of the fuel occurs.

(d) Controlling combustion by controlling fuel flammability (physical and chemical properties of the fuel- use of materials that are flame retardant)

The use of materials that are inherently flame retardant, or materials that are provided with flame retardants and inhibitors, may help reduce the likelihood of sustained combustion within electrotechnical products and may help reduce the likelihood of flame spread beyond the external surfaces (enclosures) of electrotechnical products. Several mechanisms may be involved, including interfering with heat and oxygen flow to the fuel and breaking the chemical chain reaction of the combustion process itself. The effectiveness of flame retardants and inhibitors may depend upon a number of factors, including, but not limited to, the physical configuration of the solid fuel and the presence of thermal energy sources other than from the combustion of the material itself.

LOG OF MEETING

SUBJECT: Phthalate Esters

DATE: October ~~30~~ 29, 1997

TIME: 10:00 a.m. to 12:00 p.m.

PLACE: CPSC Headquarters, Room 714

ENTRY SOURCE: Michael A. Babich, EHHS MAB

COMMISSION REPRESENTATIVES:

Marilyn Wind, EHHS; Michael A. Babich, EHHS; Robert Franklin, EC

NON-COMMISSION REPRESENTATIVES:

See attachment.

Summary:

The meeting was requested by the Chemical Manufacturers Association (CMA). Representatives from the Environmental Protection Agency and Food and Drug Administration were invited. CMA representatives gave two presentations on phthalate esters: "Understanding phthalate esters and endocrine disruption," R.M. David, and "Overview of the environmental fate, effects, exposures, and risks of phthalate esters," C.A. Staples. Copies of the slides used in the presentations were provided to each of the federal agencies in attendance. Each presentation was followed by a brief question and answer period.

attachment:

10/29/97

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