Electro-Kindling

Easily-ignited free-burning plastic materials in electrical appliances, devices, applications are described and photographs included in this article.

ELECTRO-KINDLING:
Easily-Ignited Free-Burning Plastic Materials in Electrical Applications

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The use of highly combustible plastics in the construction of today's electrical products is increasing. This is a major trend backward in fire safety. Minor electrical failures are more likely to cause serious fires when easily-ignited free-burning plastic materials are close at hand. Fire and safety professionals should understand how easily these "electro-kindling" materials ignite and how vigorously they burn. This article discusses several examples covering a broad range of electrical products.

Older samples of most electrical items are made of non-combustible or self-extinguishing materials. Today, many electrical products that used to simply "burn out" (become non-functional) on failure now will "burn up" (ignite) on failure, because they are made with electro-kindling.

A TV program about coffee maker fires included a demonstration that showed the danger vividly. [Prime Time Live, October 17, 1991 (ABC).] The coffee maker's plastic housing burned vigorously for about 1/4 hour after igniting from its own heating element. (The heating element was continuously energized, simulating a component malfunction.) Flaming plastic flowed on the test bench surface. "It's like pouring diesel fuel on your counter top and letting it burn," said the engineer conducting the demonstration. This effect is shown in Figures 1A and 1B.

FIGURE 1 BELOW: COFFEE MAKER IGNITION AND BURN TEST
[Figure 1 photos courtesy of M.Fitz, Machine Design Engineers, Seattle, WA]

- FIGURE 1A - Ignition Occurs Under continuously energized hot plate.
- FIGURE 1B - Burning Plastic Flows on Countertop.

A small amount of free-burning plastic "electro-kindling" fuels a substantial fire. The old saying, "a little goes a long way," has never been more appropriate. As an example, the portable electric heater shown in Figure 2 is mostly metal. Plastic trim pieces on the front panel are held in place by integral mounting fingers inserted into holes in the metal front panel. The mounting fingers are inside the electrical enclosure.

For the fire spread test shown in Figure 2, one of the plastic fingers next to the thermostat was ignited inside the panel enclosure, as happens from certain electrical component failures. [Recall announcement: Oil-Filled Portable Heaters, as reported in the New York Times, National Edition, August 15, 1991, p.A18]

After about two minutes, the plastic finger burned through its opening in the front panel, spreading the fire to the outside of the metal enclosure (Figure 2A). More plastic became involved, and the fire grew (Figure 2B). Burning plastic fell to the floor, igniting another plastic trim piece near the bottom of the front panel (Figures 2C and 2D). This fire burned for more than 1/4 hour. In an actual household setting, a fire of this magnitude is likely to spread further.

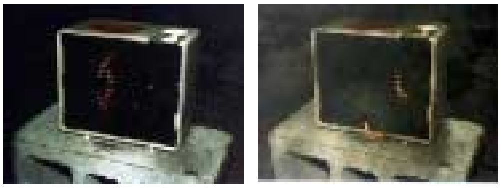
FIGURE 2 BELOW: IGNITION TEST, PLASTIC TRIM OF PORTABLE ELECTRIC HEATER

- FIGURE 2A - Fire Spreads from Inside Front panel.
- FIGURE 2B - Fire Grows as Plastic Panel Burns Vigorously.
- FIGURE 2C - Fire Spread, Flaming Plastic Drops to Floor.
- FIGURE 2D - Plastic Power Cord Cage on Bottom of Panel Burns.

In the past, portable heaters were made mainly of metal. Today, many have housings and grills made entirely of free-burning plastics. Now the heater itself can ignite, where previously only nearby furnishings and fabrics were the major concern. An example is shown in Figure 3. The heater's fan and resistance wire assembly, its central core, is supported by the plastic rear grill. Loosening of the mounting screws or breakage of the rear grill can cause the core to drop. The fan blade then rests against the housing and cannot rotate.

Without airflow, the heater wires become red hot. Heater wires resting against the housing melt and penetrate the plastic. An overtemperature (safety) thermostat cuts power, but resets itself automatically upon cooling. The cycle then repeats. Each time, the heater wires become red hot before the safety thermostat cuts the power. This continues until the unit is turned off or, in the worst case, until the housing ignites. Figure 3 shows a test of this type of failure. The plastic shroud and housing ignited after several on-off cycles, and then burned vigorously, emitting thick noxious smoke.

FIGURE 3 BELOW: IGNITION TEST, PORTABLE ELECTRIC HEATER WITH PLASTIC HOUSING.



- FIGURE 3A - Core Displaced Against Housing, Heater Wires Red Hot.
- FIGURE 3B - Plastic housing Ignited, Hole Burned/Melted through Bottom.

Even in small amounts, electro-kindling materials can be hazardous. The insulating shell of the splicing connector in Figure 4A is made of a type of thermoplastic sometimes called "drip self-extinguishing." When the inslulator is ignited in a laboratory test, a flaming drop of melted plastic falls off, extinguishing itself as it drops or after it hits the floor. The rest of the connector insulator remains intact.

The fire scenario may be quite different when the connector is used in a typical wiring system. Ignition can occur from failure of the splice connection itself or from failure of an adjacent component. There may be no safe place for a burning drop of plastic to fall. The sequence in Figure 4 is a test of this situation.

Shortly after the shell is ignited in this test, a flaming drop forms and falls to the junction box floor just below the connector (Figure 4B). The flaming drop then re-ignites the connector shell. This cycle repeats several times. More flaming plastic falls to the floor of the box. The continuing fire heats and ignites the wire insulation. Although nominally self-extinguishing, the wire insulation combustion is supported by heat from the flaming plastic shell. At the stage shown in Figure 4D, the wire insulation and the cable jacket and filler materials are involved. A small amount of electro-kindling has served to develop and spread the fire.

FIGURE 4 BELOW: BURN TEST, CONNECTOR INSULATING SHELL

- FIGURE 4A - Initial Setup of Test.
- FIGURE 4B - Connector Shell Ignited.
- FIGURE 4C - Flaming Drop of Plastic on Floor of Junction Box.
- FIGURE 4D - Fire Grows and Spreads.

The wall thermostats shown below in Figure 5 are used to control heat pumps. The top (unburned) unit shows what the bottom one originally looked like before it ignited. According to eyewitnesses, there was a short circuit in the wiring of the heat pump. Soon afterward, the occupant came into the living room to find the thermostat on fire and flaming globs of plastic dripping onto the couch. Whatever internal component in the thermostat failed due to the downstream short circuit is not known. What is known, however is that the thermostat housing did not safely contain the event. The housing ignited and served to spread the fire to the couch below. The bill for fire and smoke damage was in excess of $20,000. [Sample and incident report courtesy of M. Lane, Corporate Investigative Services.]

It could have been worse. Early detection and fast response limited the damage, and nobody was injured. Change the circumstances slightly, however, and it could have been a tragedy. The savings to the manufacturer of a few pennies on each case, by using of a free-burning (instead of self-extinguishing) plastic, turns out to be a poor buy when the reduction in fire safety factor is considered.

Failure of this type of equipment is not so rare that the fire ignition potential can be ignored. In the same large housing community as the above fire incident, there had been several other hazardous failures of the same type of thermostat.

- FIGURE 5 - THERMOSTAT WITH "ELECTRO-KINDLING" HOUSING
  (Bottom unit ignited and burned due to downstream short circuit in heat-pump wiring.)

Some large appliances are constructed mainly of combustible plastic. The water heater shown in Figure 6 ignited and burned in a home. An electrical failure occurred at the lower thermostat assembly. The plastic electrical enclosure, the foam thermal insulation, and plastic outer shell of the water heater all burned. This failure could have been reasonably contained, and fire avoided, if the materials in the immediate vicinity of the thermostat had been non-combustible. Instead, the thermostat in this design is surrounded with electro-kindling, and the result was fire ignition and spread. [Sample and incident report courtesy of M. Lane, Corporate Investigative Services.]

- FIGURE 6 - FIRE IN WATER HEATER WITH PLASTIC ELECTRICAL ENCLOSURE, FOAM THERMAL INSULATION, AND PLASTIC OUTER SHELL.

Potential ignition sources for electro-kindling also exist in low-power electrical apparatus. The "baby monitor" (wireless intercom) transmitter shown in Figure 7 (below) is an example. There are several possible internal failures that can result in ignition of the housing if it is made of an easily-ignited material. One possible failure sequence can cause shorting of the power cord that enters the case under the transformer. The cord is knotted to prevent it from being pulled out. At the knot, the power cord is in contact with the transformer (Figure 7A).

A simple component failure - for instance the shorting of a power supply diode on the circuit board - can cause the transformer to run hot. Insulation on the power cord can then soften and flow where it is pressed against the overheated transformer, allowing the wires to short together. The resulting momentary arc can cause a brief internal flame which can ignite the housing. A test of the plastic housing on this sample demonstrates (Figure 7B) that it ignites easily and burns vigorously -- it is made of electro-kindling. Flaming drops of molten plastic fall from the burning housing and continue to burn on the floor below.

FIGURE 7 BELOW: BABY MONITOR, FIRE HAZARD AND BURN TEST

- FIGURE 7A - Baby Monitor, Power Cord Touching Transformer (arrow).
- FIGURE 7B - Baby Monitor, Burn Test of Plastic Housing.

Figure 8 (below) shows how a light fixture made of electro-kindling can bring the house down. [Figure 8 photos and incident report courtesy of D.Friedman, Poughkeepsie NY.] The undamaged fixture to the right of the door is one of two identical units on either side of the door. Its companion on the left side ignited. Flaming plastic dropped to the ground, spreading the fire to the siding.

A passer-by saw the fire and smothered it with dirt from the flower bed. A lucky break. Luck, though, is an unreliable substitute for an adequate built-in safety factor. Fixtures like this used to be constructed of metal and glass, providing a substantial fire safety factor relative to this modern version made almost entirely of free-burning plastic. An identical unit could be constructed of self-extinguishing (rather than free-burning) plastic.

Overlamping may have caused this fire. Or, perhaps a bird got in through a broken lens and built a nest inside. If the fixture is non-combustible, we need only be concerned with possible ignition of nearby material. Here, however, the fixture itself ignites. Worse, once ignited, the plastic behaves as a sort of "consumer napalm," spreading the flame and greatly increasing the possibility of a penalty of death by fire for overlamping (or for failing to replace a damaged lens).

FIGURE 8 BELOW: FIRE, EXTERIOR LIGHT FIXTURE

- FIGURE 7A - Baby Monitor, Power Cord Touching Transformer (arrow).

- FIGURE 7B - Baby Monitor, Burn Test of Plastic Housing.

The implications for the fire investigator are significant. The behavior of these materials must be carefully considered in analyzing the progress of a fire. Concepts such as lowest and most intense burn may be ambiguous indicators in a fire involving electro-kindling. The thermostat fire described above and the lamp fire of Figure 8 are examples. Imagine the scene if either of those fires had progressed. The lowest and most intense burn might only indicate where the flaming electro-kindling had landed.

Investigators should also know that seemingly identical plastic items may vary enormously in combustion behavior. Subtle variations in composition can change a plastic from self-extinguishing to free-burning without noticeable difference in appearance. A burn test on a seemingly identical sample may not reflect the behavior of an item that was actually involved in a fire. For example, the baby monitor shown above in Figure 7 was produced at different times with two different plastics, one of which is a superior self- extinguishing plastic and the other - identical in appearance - is electo-kindling.

The applicable product standards permit the use of electro-kindling materials in many electrical applications, and their use is expanding. An opposite trend exists in other areas, such as carpets, and tent fabrics. The standards for these (and many other) products now require more fire resistant materials than previously allowed.

The United States Consumer Product Safety Commisssion has taken an interest in the subject. Industry and Underwriters Laboratories (UL) representatives have met with CPSC staff and expressed their position that the problem is due to inappropriate choice of materials by product designers. In their view, it can be dealt with by educating product designers. This position ignores the reality of today's product design and marketing environment, in which lowest cost for a given function is a major driving factor. One can easily derive dollar savings and profit margin figures to justify cheaper materials. Data and cost figures that might justify (to a marketing manager or accountant) the added expense of a higher fire safety factor are hard to come by and, most certainly, are beyond the reach of the average product design engineer.

Since greater fire safety factor in plastic materials generally comes at higher cost, use of materials with only the minimum performance allowed by the applicable (most often UL) standards has become the rule. The standards are serving to define what the designers will specify. Designers who cut cost to the absolute minimum are considered to be doing a good job, while designers who add materials cost by attempting to increase product safety factors beyond the minimum necessary to pass the (UL) standards are viewed as doing a poor job. Tightening the standards is clearly the most direct and effective way to address the problem. It is the only way that the fire safety factor can be increased while maintaining a "level playing field" for manufacturers in a price-conscious marketplace.

The examples shown above span a broad range of residential electrical products. From the low power baby monitor to the high power water heater, fire safety has been seriously compromised. There are countless other examples of electro-kindling materials in modern electrical products. Their use violates a basic principle of safe design of electrical apparatus; easily-ignited and free-burning materials should not be used where they might be ignited by electrical failure.

To restore an adequate fire safety factor in electrical products, the relevant standards must be changed to eliminate the use of highly combustible materials near potential electrical ignitors. From the fire safety point of view, electricity and combustibles don't mix.

.More Information:

Electro Kindling, electric failures ignite combustibles. - A Case Study By Williams, Spinelli, & McIntyre
Plastic Cased Heater Catches On Fire