AC ADAPTER FIRE CAUSATION

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In the average US home, it is not uncommon to find numerous AC adapters plugged into wall outlets at all times. Table I lists a number of appliances that make use of these types of adapters. The basic AC adapter can generally fall into one of two types: an AC to AC adapter and an AC to DC adapter; the former is also known as a filament transformer or step-down transformer. Except for devices known as "switch mode" adapters (commonly used on notebook computers and LCD TVs), all AC adapters fall into one of these two categories. The focus of this work will be directed on AC to DC adapters, although much of the general theory applies to both AC transformers and AC to DC adapters.

TABLE I: Appliances using AC adapters

Answering machine	Video game
Cordless phone base	Camcorder charger
Rechargeable flashlight	Security system camera
Calculator	Adding machine
Sprinkler system controller	Police scanner
Burglar alarm system	Back massager
Cordless drill power base	Cellular telephone charger
Infant monitor	

An AC to DC adapter will always consist of a step-down transformer (just like an AC to AC adapter), plus rectification, filtration, and possibly regulation components. A further division can be made among the various AC adapters; some are made just to charge batteries to allow proper operation (such as for a flashlight or cordless drill), while other adapters provide the power necessary for continuous operation of an appliance while receiving power from the adapter. Generally speaking, adapters that are just used to charge batteries are of smaller size and power than are the types which are designed to directly operate an appliance

The question that often arises is whether or not these types of adapters can cause fires. The answer is one that might seem vague but cannot be disputed: "it depends". Whether or not a given adapter is capable of fire causation greatly depends on its design, loading, and use. Explored within this paper are both the theoretical background of AC adapters and actual testing of AC to DC adapters for fire causation.

REASON FOR UTILIZATION

In Table I, numerous uses for AC adapters were given. One of the questions that must be asked is why it is necessary for an appliance to use such an adapter; i.e. why not make the adapter part of the appliance? More specifically, lawn sprinkler systems and security systems require the step-down transformer anyway, why not make it part of the appliance, as is commonly done with many electric systems (stereos, radios, televisions)? There are numerous answers to these questions, as is shown in Table II.

Table II does not show the ONLY reasons for using AC adapters; there are indeed others. But these are the major reasons, and in understanding them, we are better able to analyze a fire damaged appliance and comment on its propensity (if any) to cause a fire.

TABLE II: AC Adapter Utilization

EASE OF INSTALLATION I
1. The two systems just mentioned (alarm and sprinkler) are required to have a permanent installation, usually executed by a tradesman. In that these individuals are usually not licensed electricians, they are not legally permitted to perform hard wired AC (120 volt) installations. By keeping the transformer male blades (plug) as the only contact with 120 VAC, the designer has insured that the appliance can be installed by a person who is not a licensed electrician.

EASE OF INSTALLATION II
2. All the wiring required after the AC adapter will be of low voltage design, once again alleviating the need for a licensed electrician. Furthermore, by using low voltage throughout the majority of a design, we have constrained the areas of concern from an electrical shock standpoint to one area—the wall outlet and the plugged-in adapter.

ELECTRICAL NOISE
3. Because transformers generate magnetic fields, it is possible for the AC adapter to interfere with the operation of the appliance. By separating the transformer from the main appliance, it reduces electrical noise and/or the design constrains necessary to minimize the noise (shielding).

FIRE AND SHOCK PREVENTION
4. By having the AC adapter/transformer separate from the main appliance, one increases fire and shock prevention to the end user; in that the 120 VAC power is constrained to just one part of the system, it also allows the designer more flexibility in designing the rest of the system.

EASE OF DESIGN
5. Components that might require a great degree of robustness when operating off of 120 VAC now can be relaxed in terms of specification. As an example, it is not necessary to use flameproof resistors when the output of the AC adapter is not capable of supplying enough energy to cause a flame. As a result, the majority of the appliance circuitry can be constructed using low voltage techniques.

EASE OF REPAIR I
6. The appliance with an adapter in now much easier to service, in that a repair technician does not have to worry about receiving an electrical shock; persons normally do not get hurt from the low voltage that comes from the AC adapter.

EASE OF REPAIR II
7. It is well known that heat affects the potential for breakdown of every electrical appliance. By isolating much of the heat to one area (in the AC adapter), we have helped to insure that a failure due to heat will probably occur in the AC adapter and not in the rest of the circuitry. AC adapters are inexpensive, easily replaced and require very little technical knowledge.

THEORY OF OPERATION

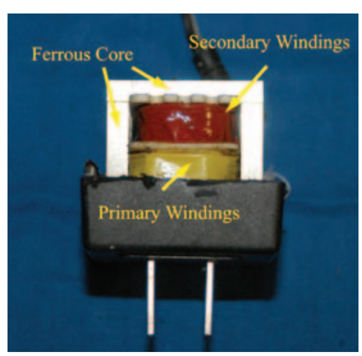

FIGURE 1: *A Step-down transformer consists of two coils of wire that share a common magnetic core.*

The basic step-down transformer consists of two coils of wire that share a common magnetic (ferrous metal) core. A view of such a transformer is shown in Figure 1. The primary coil is placed across the nominal 120 VAC line, and the secondary coil provides the output for the appliance. The two coils, in theory, transfer the same amount of power. However, the voltage ratio between the two coils is set by the turns (N_i) ratio of the transformer. (See Equation 1)

(Equation 1)

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

Moreover, the current ratio between the two coils of the transformer, primary and secondary, varies inversely with the turn ratio *(Equation 2)*.

(Equation 2)

$$\frac{I_p}{I_s} = \frac{N_s}{N_p}$$

As an example, consider a transformer with 1000 turns of wire on the primary and 100 on the secondary. The output voltage is then 12 volts if the input voltage is 120 volts. Similarly, if a 12 volt, 12 watt light bulb is attached to the output of the transformer, it will draw 1 ampere of current (per Ohms law). Thus, the secondary current is 1 ampere, while the primary current is 0.1 amperes. If this is an ideal transformer (one that does not heat up), the power calculated for the primary (120 volts x .1 amperes, or 12 watts) should equal the power calculated for the secondary (12 volts x 1 amperes, or 12 watts). For a more in depth treatment of transformers, the reader is referred to the Flanagan's text[1].

With regards to the construction of the transformer show in Figure 1, the two coils of wire (primary and secondary) are easily distinguished from one another. Since the primary of a step-down transformer will always have less current than the secondary, it will have the smaller gauge (diameter) of wire. Similarly, the secondary will have the larger diameter of wire (these observations are true for all step-down transformers). Figure 2 shows a cut-away section of a transformer recovered from a fire scene. The primary side has numerous wires of smaller diameter, while the secondary has much fewer wires that are each of a greater diameter. (Typically, the windings are much more orderly; the lack of evenness is due to fire damage.)

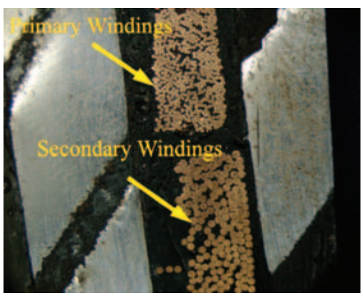

FIGURE 2: *Cut-away section of a transformer showing the primary side having numerous wires of smaller diameter. The secondary has much fewer wires of a greater diameter.*

Another feature of most transformers built today is that they are of split bobbin construction. On such a transformer, separate portions of a plastic bobbin separate the primary from the secondary coils. Figure 3 shows an arrangement of the windings of a transformer, with the primary separated from the secondary. Note that the plastic separating the two coils means that they are electrically isolated from each other by several layers of insulation (plastic bobbin and enamel insulation on the wiring). If one were to try and measure the DC resistance between the primary and secondary coils, the resistance would be in the tens to hundreds of mega-ohms; no current can flow between the two sides. This electrical isolation between the two coils (primary and secondary) and the low voltage output is why the NEC allows Class II (Low Voltage) wiring to be used on the output of such a transformer or adapter; in that the output voltage has no ground reference (due to the isolation) and is of low voltage, it is extremely difficult for someone to be electrically shocked by one of these adapters.

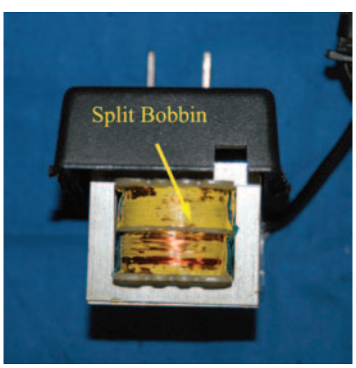

FIGURE 3: *Arrangement of the windings of a transformer with split bobbin construction.*

One basic premise of a transformer is that it cannot be used to carry DC. A transformer must always be operated on AC. In order to operate a DC appliance from the standard 120 VAC wall outlet, the AC adapter must not only step down the voltage, but then convert it to DC. This process consists of one, two, or sometimes even three separate stages; sequentially, these are rectification, filtration, and regulation. The rectifier stage consists of one or more diodes (or rectifiers) which always carry current in one direction only. The 60 Hertz sine wave which enters from the transformer exits the rectifier stage in a series of 1/120 second half waves. Thereafter, if a filter is present, the half sine wave takes on the appearance of a somewhat straight line (i.e. a constant voltage); any lack of smoothness in the voltage is referred to as ripple. And finally, the ripple is somewhat eliminated by the regulation stage. The schematics and voltage traces in Figure 4 show typical circuits and voltage waveforms for the three stages of AC to DC step-down and conversion.

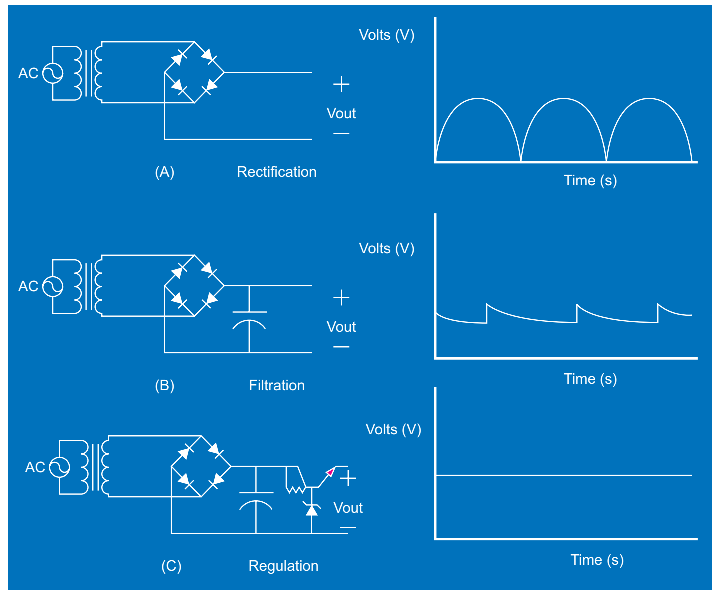

FIGURE 4: *The Three stages of AC to DC step-down and conversion: Rectification, Filtration and Regulation. Typical schematic and voltage traces of circuits and voltage waveforms.*

THEORETICAL FAILURE AND FIRE CAUSATION

As with most electrical appliances, AC adapters can fail and cause fires. However, proper attention to both design and manufacture should eliminate most potential AC adapter fires. In terms of fire causation, the most common initiator seen by the writers is that of the shorted output. In this scenario, a short circuit occurs in the output wiring (the lead that runs from the adapter to the appliance). As noted earlier, output wiring from an AC adapter is low voltage wiring, and as such, is not as robust as wiring used to carry 120 VAC. In that this wiring is not as durable, it is much easier to damage such that a short circuit can occur.

When a short circuit occurs on the output wiring of an AC adapter, the adapter will begin to overheat. This overheating will be substantially confined to the AC adapter chassis, and most particularly, the transformer. Because a transformer's windings are not subject to the normal wear and tear that is seen on the output power lead, the windings are insulated with a thin coating of lacquer. This lacquer is designed to handle higher temperatures than the standard thermoplastic used on output leads, with the trade-off being that the lacquer is much thinner than conventional thermoplastic insulation used on low voltage wiring.

The insulation temperatures for wound magnetic wire are separated into several different classes (Table III)[2]. Common insulation for windings on an AC power adapter is rated at 105°C or Class A[3]. The fine gauge wires (and thus resultant I^2 R losses) which are now powering a

TABLE III: Installation Classes

CLASS	TEMPERATURE (°C)
O	90
A	105
E	120 (IEC)
B	130
F	155
H	180
N	200
R	220
S	240

shorted output are the reasons for the overheating. As the wire overheats the wire and insulation are both heat stressed and the insulation starts to degrade. The expected life of the insulation at elevated temperatures follows as an Arrhenius relationship[4]. More specifically, the average life hours (L) before failure is logarithmically dependant on the temperature (Equation 3, where A and B are insulation constants and T is the absolute temperature).

(Equation 3)

$$L = A \cdot e^{\frac{B}{T}}$$

With a shorted output the temperature rises much higher than with normal operating current. The Arrhenius relationship shows that the higher the temperature, the lesser the time (measured in hours) until there will be insulation failure caused by dielectric breakdown. (See Figure 5)

Should the temperature continue to rise unchecked (as might occur if the output windings were shorted), there will be a point reached where integrity is immediately lost and shorting/breakdown occurs. While the Arrhenius rule predicts shorter lifetimes for more severe operating conditions, there is a finite upper limit—once the insulation has degraded to the point that shorting and faulting occur, the lifetime is zero hours.

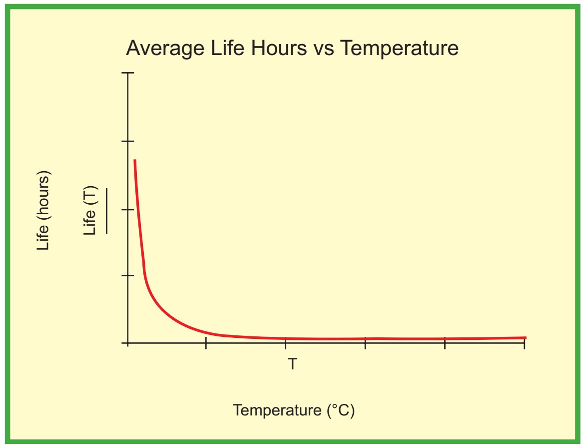

FIGURE 5

So how could a fire occur? As the transformer heats up when its output is shorted, the heat causes the insulation on the wire to pyrolyze, emitting visible "smoke". This smoke, which is the pyrolyzed lacquer from the insulation, can often be ignited; all that is needed is a spark. To get a spark to occur, a sudden break in the transformer windings or an arc from one layer of windings to the next will suffice. When the output is shorted, the generated heat creates a thermal stress on both the wiring and insulation and the materials expand. Since they are two different materials, the rate at which they change dimensions will be different. Eventually, a point is reached were either the insulation fails or the wiring (copper windings) fails. When this happens one or two things can occur. If the wiring snaps, a small arc will occur; this arc can cause ignition of the combustible vapors, provided they are in the right concentration (LEL and UEL considerations). If the insulation fails, then arcing might occur on the windings at adjacent wires. Whether or not this arcing will occur depends on the distance, voltage difference between the wires, the level of pyrolysis, and the conductive nature of the gaseous products from the pyrolysis; all of these are factors that figure into Paschen's equation (For an in-depth discussion of this effect, the interested reader is referred to Naidu et al text[5]).

When the arc occurs, it is capable of igniting the insulation vapors, given the proper stoichiometry. However, at the same instant the arc occurs, the adapter dies, (i.e., current flow stops), which in turn stops the electrically induced heating. The initial flaming vapors then have

TABLE IV: ADAPTER SAFETY DESIGN

THERMAL FUSE
A thermal fuse sometimes referred to as a TCO can be included in the transformer. Sometimes these fuses are buried in the windings, where they are not visible. A common fuse rating is 105°C (221°F). This fuse will electrically open up before the insulation on the windings significantly degrades; when the fuse opens, current flow stops and the adapter must be thrown away. These TCOs are similar to those used on numerous appliances, such as coffee makers and curling irons.

OVERCURRENT FUSE
The overcurrent fuse can react to both overload and short circuit conditions. When it trips, as with a TCO, the adapter is no longer serviceable. One virtue of this fuse is that it is encased such that when it trips, the resultant arc cannot ignite nearby combustible fumes. Design strategies vary, such that some designers place fuses in series with the primary windings, while some situate fuses in the secondary circuit.

FUSIBLE LINK
The fusible link is a form of an overcurrent fuse; however, it is not usually enclosed in a housing. In some designs, it consists of a small length of copper wire that is usually smaller than the wire size for the transformer winding. In other designs, a piece of lower temperature (eutectic) wires is used. As an example, one video game analyzed by the authors uses an AC adapter that has a length of #39 AWG wire present, in series with the primary windings. If a short circuit occurs on the output of adapter, the fusible link works like a fuse and opens up. The disadvantage of this scheme is that the fusible link is not hermetic (sealed from the atmosphere). However, when properly designed and sized, the fusible link will open before there are significant pyrolysis products from the overheating of the insulation on the windings.

RECTIFICATION/REGULATION
Some transformer protection is divided by rectification / voltage regulation portion of an AC adapter. It should be noted that a designer does not include a rectifier or voltage regulator simply because it will help to protect the transformer against short circuits; rather, the voltage and current requirements of the appliance being served dictate the design. Nevertheless, these components do limit the fault current somewhat. As an example, the fault current through one transformer was 6 amperes for a short, but dropped 4.6 amperes when a single wave rectifier circuit was in place.

IMPEDANCE PROTECTION
The impedance protection of a transformer is a concept that is difficult to explain to those who are not electrical engineers. Basically, a transformer will have both resistance and inductance, and both of these will limit the amount of fault current in a short circuit. Resistance is the limitation of current flow brought on by the resistance of the copper wire. Inductance (or inductive reactance) is an opposition to current flow brought about by the fact that the transformer is a magnetic circuit; the inductance also refers to the ability of the circuit to store energy. In these types of circuits, the common form of Ohms Law (V = IR) does not apply. Rather, the formula V = IZ applies, where these quantities are vectorial in nature.

to produce enough heat from combustion to sufficiently cause more out gassing and pyrolysis of the windings. As we will show in this paper, this is a formidable task—one making AC to DC adapter fires virtually impossible to occur. The initial flame, even if it does occur, has insufficient energy available to maintain the continuing pyrolysis of the insulation.

A second theoretical way that a fire could occur is for the overheating transformer to cause the plastic housing to pyrolyze and then ignite. The difficulty with this theory is that the transformer must continually operate at close to 600°F in order to sufficiently transfer heat to bring about the pyrolysis of what is usually UL 94 HB plastic on the housing. The transformer core (windings) cannot sustain 600°F operations, and will fail before sufficient heat can be transferred to the housing to cause a fire.

PROPER ADAPTER DESIGN

The process of creating a fire from an AC adapter appears simple; one has to wonder how an adapter can be designed so as to prevent a fire. There are numerous design tricks, not always apparent, that help prevent AC adapter fires. Many of these design techniques are described in Table IV. One has to understand these design techniques before analyzing an AC adapter circuit to see if it could have caused a fire.

What the fire investigator needs to remember here is that a transformer can be designed with a large number of turns of wire, such that it has high reactance; this reactance will limit the fault or short circuit current to a level that should not cause the transformer to overheat. As an example, UL 1585 does not require that an impedance protected transformer have a thermal protector or fuse in its circuitry[6].
(See Table IV)

TESTING AND RESULTS

The main thrust of this paper is to determine whether or not fires can be caused by AC to DC adapters. To that end, a number of AC to DC adapters were obtained and tested. Testing made use of short circuits created on the output leads (power leads) to the device. Table V lists a number of different AC to DC adapters that were tested. Prior to testing, each adapter was examined via fluoroscope to determine the type of circuit present (transformer with rectifier and filter circuit, transformer with rectifier/filter and voltage regulator). The fluoroscope also allowed determination of how the transformer was oriented, and the location of protective devices.

TABLE V: Tested Transformer Specs

#	Device	Voltage	Current	Protection Scheme	Internal Circuit
1	Phone	6 VDC	300 mA	TCO	Full Bridge/Filter
2	Phone	9 VDC	200 mA	Current Limit	Full Bridge/Filter
3	Phone	9 VDC	200 mA	Current Limit	Half Bridge/Filter
4	Phone	12 VDC	300 mA	Current Limit	Half Bridge/Filter
5	Battery Charger	9 VDC	100 mA	TCO	Full Bridge/Filter
6	Battery Charger	3 VDC	240 mA	Current Limit	Half Bridge/Filter
7	Battery Charger	6 VDC	500 mA	Current Limit	Half Bridge/Filter
8	General Use	12 VDC	150 mA	Current Limit	Full Bridge/Filter
9	Fountain Pump	27 VDC	800 mA	TCO	Full Bridge/Filter
10	Toy Batt Chgr	6 VDC	1000 mA	TCO	Half Bridge/Filter
11	Phone	9 VDC	450 mA	Current Limit	Full Bridge/Filter
12	Multi-Purpose	3 VDC	200 mA	Current Limit	Half Bridge/Filter/Reg

Normal input voltage for the adapters is 120 VAC; for the purpose of accelerating the testing and increasing the likelihood of a failure, testing was conducted at an input voltage of 210 VAC. This voltage was applied and the adapters were subjected to direct shorts. During the test, the current and temperature were monitored. The temperature rise on the windings was measured and computed using an average change in resistance technique[7].
The technique was derived from the relationship expressed by Equation 4, where R is in ohms and t is in degrees Celsius (°C).

(Equation 4)

$$\frac{R_2}{R_1} = \frac{t_2 + 234.1}{t_1 + 234.1}$$

Each test was run until the adapter failed or an open circuit was detected. For all cases the maximum current was observed during the start up of the test. The current was seen to drop over time; indicating an increase in the resistance of the windings. The time to failure varied from adapter to adapter. For all the tests, the variation in time could be broken down into four categories—less than 2 minutes, 10-15 minutes, 20-30 minutes, and greater than 1 hour. None of the adapters were observed to start a fire. Smoke was noted briefly coming from transformer 9 but only lasted several seconds. The highest average temperature on the transformer's primary windings were recorded in excess of 250°C (482°F). In many of the tests, the outside plastic casing was considerably warm to the touch, but for no test did it fail or severely melt.

After cooling, the transformers were inspected to determine the cause of failure. In all cases, the secondary windings were still intact. The insulating tape and packing surrounding the transformer windings was still intact on both primary and secondary windings. The point of failure had occurred by a fault to the primary windings. The failure occurred either by one of two ways—either the thin gauge wire connecting the windings to male lead in blades had fused and opened (*Figure 6*) or the TCO had fused and opened up protecting the windings from damage. Table VI list the transformers tested and the respective, temperature, current, failure mode.

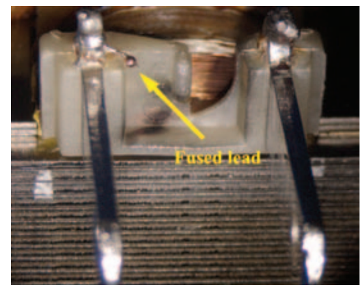

FIGURE 6: *The point of failure of the transformer was caused by a fault to the primary windings.*

TABLE VI: Transformer Test Results

#	Device	Failure Time	Max Temp*	Max Current*	Failure Mode
1	Phone	15 min	220°C	1.98 A	Open TCO
2	Phone	30 min	226°C	0.82 A	Fused Primary
3	Phone	15 min	254°C	2.34 A	Fused Primary
4	Phone	10 min	261°C	2.34 A	Fused Primary
5	Battery Charger	2 hr 18 min	154°C	0.709 A	Open TCO
6	Battery Charger	33 min	247°C	1.26 A	Fused Primary
7	Battery Charger	10 min	224°C	4.92 A	Fused Primary
8	General Use	24 min	254°C	1.35 A	Fused Primary
9	Fountain Pump	30 sec	198°C	13.8 A	Open TCO
10	Toy Batt Charger	1 min	189°C	11.66 A	Open TCO
11	Phone	2 min	148°C	5.47 A	Fused Primary
12	Multi-Purpose	2 hr 22 min	218°C	2.34 A	Fused Primary

*NOTE: Max temperature measured on primary windings, max current on secondary windings

Further testing was conducted on the transformers where the TCO protecting the circuit had opened. The TCO was by-passed using a jumper clip and 210 VAC was applied to the transformer. Using infrared techniques to view the temperature gradient between the windings, it was apparent that the heat was more intense on the primary windings (see *Figure 7*). In all cases the transformer failed but no fire was observed. It was evident after investigating these failures what had occurred. The dielectric insulation appeared to have failed exposing adjacent windings and consequently causing arcing as discussed previously. The breakdown was evident by the appearance of an effervescent brown lacquer on the surface (see *Figure 8*). The adapters lost power almost instantaneously to the failure. There were no signs of charring or ignition to the plastic housing.

DISCUSSION

The testing done by the authors show that it is extremely difficult to start a fire from an AC adapter. In every instance, the adapter shut down electrically before a fire was started. The NEC states that Class II appliances and wiring do not normally cause fires, essentially because of the low voltages involved. We are in general agreement with that observation. The one major disagreement with the NEC would result

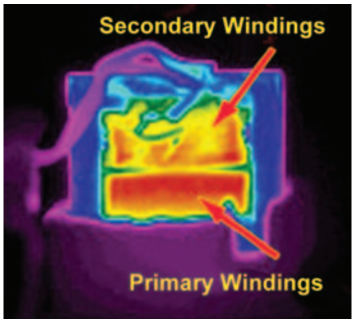

FIGURE 7: *Infrared techniques revealed that the heat was more intense on the primary windings.*

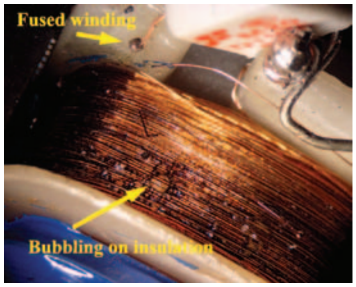

FIGURE 8: *Transformer breakdown was evident by the appearance of an effervescent brown lacquer on the surface of the windings. The adapters lost power almost instantaneously.*

from a high resistance connection. Given a high resistance connection, the underlying factors for heat production are resistance and current. When a high resistance connection is coupled with inductance (a form of energy storage), the possibility for a fire increases dramatically. We can envision the high resistance connection as being the source for a fire in an AC adapter.

In examining an adapter for fire causation, there are several key items to look for. One of the most telling is the plastic insulating tape (often red, blue, green or yellow in color) placed around the outside of the windings. If this tape is intact, it is unlikely that the transformer caused the fire. If the fire is severe, however, the tape will have been destroyed regardless of causation. Another telltale sign relates to differences in winding damage. On many short circuited transformers, the primary winding insulation will have changed to a much darker color than the secondary winding. This would indicate a great amount of heat being dissipated in the primary. If the heating were caused by an external heat impingement, one would expect the heat damage to be relatively uniform for the two windings.

The presence of arcing does not mean that a transformer or AC adapter started a fire. Most small transformers are intentionally designed such that a shorted output will cause an arcing failure in the primary windings. This failure is often on the lead-in-wire from the male blade to the transformer winding. When this wire snaps (fractures), thereby cutting off current, a momentary arc does occur; examination under a microscope will show the rounded ball on the wires end that was created when the arc was generated. Often, all one can conclude is that the output was shorted, causing a failure in the primary.

Further caveats relate to the atmosphere that an adapter is found in, as well as the type of plastic casing that the adapter is housed in. In regards to atmosphere, one must consider ambient temperature, the nature of any combustible materials near the adapter, and vapors that may be explosive. With regards to the plastic casing, one needs to know its UL 94 characteristics—HB, V0, etc. All of these factors will have some bearing in an investigation. That being said, however, we have never seen a transformer core get sufficiently hot on an AC to DC adapter that it would cause substantive pyrolysis of the housing.

Anecdotal information abounds about a great number of fires that years ago were caused by a telephone AC adapter for the famed Princess style of phones; the AC adapter were used for lighting the dial of the phone. More recently, one of the authors suspected that a video game power supply caused a fire. In that the video game was no longer manufactured; several pawn shops were called in an attempt to locate an exemplar video game. At one pawn shop, the proprietor asked if the author wanted to buy the whole game or just the AC adapter power supply. The pawn shop owner then explained that numerous persons came in to buy just the AC adapters, because these adapters would overheat and start smoking. Testing by one of the authors confirmed the anecdotal information; when the adapter was overloaded, it caught fire. Circuit analysis showed that it had no protective components in its design, the windings were not designed to fail on the primary side, and the plastic would self sustain a flame.

Given the abundance of adapters in a home, it can be difficult at times to tell what appliance was served by what adapter. In one fire case involving a sprinkler control box, we found a transformer that did not dimensionally match the manufacturers. The transformer was claimed by some to have belonged to a cordless phone. The transformer was potted in clear Buehler acrylic. After curing, a band saw was used to section the transformer, followed by polishing. The number of turns in the primary and secondary could then be counted, allowing the computation of a theoretical voltage, based on the turns ratio. The previous shown Figure 2 shows a similar cross section of the primary and secondary of a transformer.

SUMMATION

Testing of numerous AC to DC adapters did not show that they can be causative of fires. However, the investigator is advised to always test numerous adapters of the same type in order to verify this in a given fire. The investigator needs to understand the workings of the adapter, to include both its safety features and its failure modes. Rigorous testing, combined with an equally vigorous technical investigation of a fire scene, will usually lead the investigator to the right conclusion. ●

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