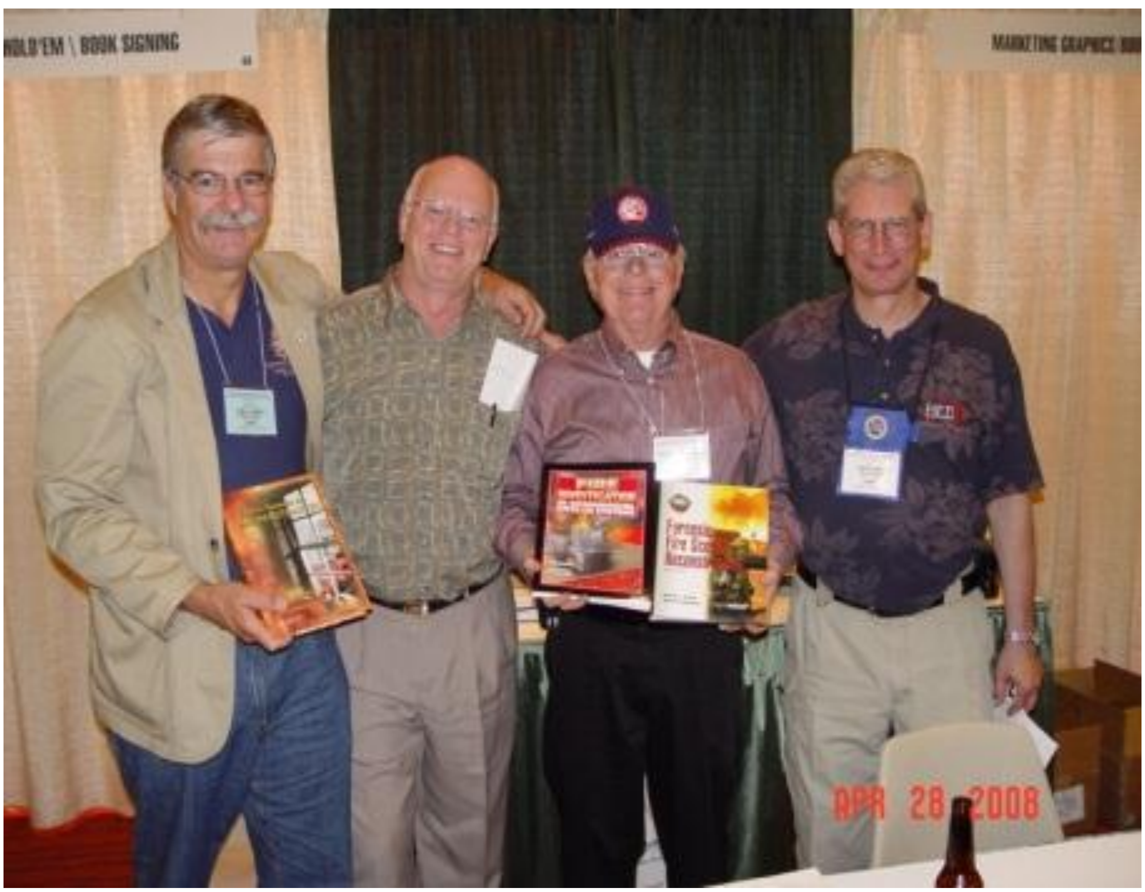
Chapter Eighteen – Appendix



John Lentini, Phil Ackland, Mike Schlatman and Dave Icove at the 2008 IAAI convention in Denver

Appendix

Articles

NFPA 921 Guide for Fire & Explosion Investigations, 2011 Edition

An Update, by Randy Watson, C.F.I., C.F.E.I., Senior Fire Investigator, SEA, Ltd.

Introduction

The 2011 edition of NFPA 921 Guide for Fire and Explosion Investigations was approved by the NFPA Standards Council on December 14, 2010 and was given an effective date of January 3, 2011. NFPA 921 was also approved as an American National Standard on January 3, 2011. NFPA 921 is developed by the Technical Committee on Fire Investigations through the NFPA consensus standards making process. The scope of the technical committee is to have primary responsibility for documents relating to techniques to be used in investigating fire. The 2011 edition is the seventh edition since the committee was assembled in 1985. The scope of NFPA 921 is to assist individuals with the responsibility of investigating and analyzing fire and explosion incidents. The purpose is to establish guidelines and recommendations for the safe and systematic investigation or analysis of fire and explosion incidents. In the 2011 edition, the document continues to raise the bar of professionalism in fire investigation. The following discussion presents an overview of the 2011 edition, including highlights of principal changes.

The 2011 edition expanded by approximately 12% over the 2008 edition. With 341 pages and 28 chapters, the document can generally be broken down into thirds. The first nine chapters are generally background knowledge. This section contains the foundational information an investigator should know. Chapters such as Definitions, Basic Methodology, Fire Science and Fire Patterns are found in this section of the document. The middle third of the document (chapter 10 through 20) contains information on conducting the investigation. This section of the document contains vital chapters such as Origin Determination, Cause Determination, Documentation, Physical Evidence and Safety. The last third of the document contains chapters on incident topics. Chapters such as Explosions, Incendiary Fires, Vehicle Fires, Marine Fire Investigations and Management of Complex Investigation are found in this section.

Courts all around the country are recognizing and using NFPA 921 as their tool in evaluating fire and explosion cases. Since the Daubert, and its subsequent decisions, the judge was given the role of gate-keeper of expert testimony by the Supreme Court. In their role as gate-keeper, the judge must evaluate the reliability of expert testimony prior to allowing that testimony to be heard by the jury. Increasingly, the courts are turning to NFPA 921 to assist them in this gate-keeper role. In various documented cases, the courts have referred to NFPA 921 as “the gold standard,”[1] the “bible of arson forensic science,”[2] and the “national standard with regard to appropriate methodology[3].” In one New York State Supreme Court case[4], NFPA 921 was referred to as an “I.A.A.I. standard” and “recognized as authoritative by ATF.” In these and other cases, the courts are using NFPA 921 as their measuring stick in evaluating expert testimony in fire cases. In Oklahoma, the state senate passed a resolution calling NFPA 921 a “standard of care for fire investigation.” The resolution “urges the judicial branch, law enforcement agencies, and other relevant government entities in Oklahoma to employ NFPA 921 when conducting fire investigations.”[5]

New for NFPA 921 2011 Edition:

The 2011 edition expanded from 305 pages in the 2008 edition to 341 pages. Significant changes are documented in those additional thirty six pages. The following summarizes the new changes.

Outline of major changes for NFPA 921 2011 Edition:

- Chapter 3, new definitions added.
- Chapter 4, new section on “Review Procedure.”

[1] McCoy v. Whirlpool

[2] Babick v. Berghuis

[3] Workman v. Electrolux

[4] Fici v. State Farm

[5] Oklahoma Senate Resolution No. 99

- Chapter 6, new section discussing analysis of smoke detectors.
- Chapter 18, complete revision of the Cause Chapter.
- Chapter 21, complete revision of the Explosion Chapter.
- Chapter 23, complete revision of the Fire Deaths and Injuries Chapter.
- Chapter 25, expanded discussion on agricultural equipment and recreational vehicles.
- Chapter 26, complete revision of the Wildfire Chapter.

Of the new definitions added to chapter 3, "Competent Ignition Source" is impacting. Competent Ignition Source is defined as "an ignition source that has sufficient energy and is capable of transferring that energy to the fuel long enough to raise the fuel to its ignition temperature."[6] This is especially important when cause analysis is being conducted. For an ignition source to be competent, it must have sufficient energy, long enough to raise the suspected fuel to its ignition temperature. If the suspected ignition source cannot produce sufficient energy, then it cannot be considered competent for the fuel that was believed to be ignited. This becomes especially important when the cause is discussed in Chapter 18.

A new section was added in Chapter 4, addressing the review of reports. Many in the fire investigation industry claim their reports are "Peer" reviewed. The committee identified three categories of review. The most basic form of review is "Administrative." This is simply a review for items such as spelling, grammar and formatting. While this is an important process, it provides no technical review of the investigation or analysis. The second type of review discussed is that of "Technical" review. This type of review is conducted by a qualified investigator with access to all the necessary documentation. A "Technical Review" can act as an additional test of various aspects of the investigators work. This type of review is often performed by coworkers or supervisors. The reviewer needs to be aware of various biases that may come into play as a result of working relationships. The third form of review is "Peer." Peer review is a formal procedure that is generally employed in prepublication of scientific and technical documents. This type of review is often done anonymously; neither the author nor reviewer knows the identity of the other. Because of the anonymity, the author and reviewer have no interaction and questions cannot be asked or issues clarified. This section points out that reviews by supervisors and coworkers are appropriately characterized as "technical reviews."

Section 6.2.10.3, "Enhanced Soot Deposition on Smoke Alarms" was added to the chapter on Fire Patterns. The activation of smoke alarms in fires with fatalities and injuries is an especially critical issue. Recent research and testing has shown that if an alarm activates in a smoky environment, soot particulates form identifiable patterns on such surfaces of the smoke alarm as the internal and external surfaces of the alarm cover near the edges of the horn outlet and horn disks themselves. If the alarm does not activate, those patterns will not be present. Special cautions are outlined concerning the documentation, collection, preservation and analysis of the detectors.

No other revision to the 2011 edition has received as much attention as Chapter 18, "Cause Determination." This chapter was completely revised to reflect the use of the Scientific Method in establishing the cause of a fire or explosion event. This revision outlines how each step of the scientific method is addressed in establishing the cause of a fire. The overall methodology, data to be collected, analysis to be conducted and the development and testing of the hypothesis is discussed in detail. The section that has drawn the most discussion is 18.6.5, "Inappropriate Use of the Process of Elimination." Some refer to this as the "Negative Corpus" section. For the reader to have a complete and accurate view of this section, the entire chapter needs to be read and understood. The term "Negative Corpus" is applied when an investigator claims to have eliminated all potential ignition sources and then claims such methodology is proof of an ignition source for which there is no evidence. The process of establishing a cause when there is <u>no evidence</u> is not consistent with the Scientific Method and should not be used.

A fire cause involves three critical elements. Those elements are first fuel, ignition source and ignition sequence. The cause hypothesis should be based on fact associated with those three elements. The facts can be established through evidence, observations, calculations, experiments and lays of science. Speculation cannot be included in the analysis.

[6] NFPA 921 2011 Edition, section 3.3.33

The Explosion Chapter was completely revised in the 2011 Edition. This chapter had not been significantly revised in several years. As a result, the committee felt that in light of the advancements in research and methodology since the last major revision, a general reorganization and update to the current science and technology dealing with the investigation of explosions was warranted. A significant number of figures and references were added during the revision.

Chapter 23, “Fire Deaths and Injuries” was completely revised. This chapter had not been significantly revised since it was included in the 2001 edition. The intent of the revision of this chapter was to provide the reader with a basic knowledge associated with fire related deaths and injuries, and then provide details regarding the implementation of this knowledge in the field. The various mechanisms of death and injury are discussed in detail. The goal is to provide the reader with what information is available and how that information can assist in the investigation.

Significant additions were made to Chapter 25, “Motor Vehicles.” The section on Recreational Vehicles was expanded from four short paragraphs to several pages. Recreational Vehicles have many unique systems and components. These various systems and components are discussed in detail to provide the investigator with basic knowledge of their function and operation. The other large addition to this chapter involved expanded discussion on Agricultural Equipment. This section expanded from one paragraph to four pages. Both self-propelled and drawn implements are addressed. The various classifications of equipment as well as the unique issues that relate to agricultural equipment are discussed. A brief discussion was added to this chapter addressing Hydrogen-Fueled Vehicles. This is mainly a safety discussion, making the investigator aware of unique issues related to the systems inherent to these types of vehicles. Some of these issues related to the hydrogen fuel itself and others relate to the components which are necessary for the system to operate.

The final chapter to see a significant revision was Chapter 26, “Wildfires.” There were significant contributions to this revision from those specializing in the investigation on wildfires. As a result, this chapter was completely reorganized and rewritten. A significant number of figures and references were added.

NFPA 921 is currently being revised for the 2014 edition. This will be a monumental edition for 921. NFPA has authorized the publication of 921 in color. This is something the industry has been requesting for many years. The committee has as a goal to replace as many of the images in the 2011 edition with color as possible. In addition, having the ability to include color images in the document will open up many resources which will provide great clarification of the text and examples to the reader.

How to Obtain a Copy of NFPA 921

The current 2011 edition of NFPA 921 is available by calling 1-800-344-3555.

Oklahoma State Senate Adopts Resolution Urging the use of NFPA 921 and the Scientific Method

Oklahoma becomes the first state to take legislative action concerning the Scientific Method and NFPA 921. The Oklahoma State Senate has approved Resolution No. 99 which indicates “the only appropriate means for identifying arson is to use the Scientific Method” and urges the use of NFPA 921, calling it “the standard of care.”

This resolution acknowledges the high cost of arson related crimes in both lives lost and property damage. It also recognizes that many of the “accepted methods for identifying incendiary fires” in the past have now been proven to be unreliable and have resulted in the misclassification of fire causes as incendiary. As a result, possible wrong convictions for arson have occurred. The resolution places an obligation on the government to review arson convictions obtained using evidence now known to be unreliable. This also urges government and private attorneys as well as fire investigators to review “questionable arson convictions.” This resolution could have significant implications on previous arson convictions.

In addition to urging review of “questionable arson convictions,” the Senate has taken a stand on the use of NFPA 921. In addition to calling NFPA 921 “the generally accepted standard of care,” the resolution states, “That the Oklahoma State Senate urges the judicial branch, law enforcement agencies, and other relevant government entities in Oklahoma to employ NFPA 921 when conducting fire investigations.” The guiding methodology of NFPA 921 is that of the Scientific Method. This resolution recognizes the importance of both the methodology advocated in the Scientific Method and the recommendations contained in NFPA 921.

As a result of the Senate indicating that the only appropriate methodology to use is that of the Scientific Method and that NFPA 921 should be used as the standard of care, anyone testifying in a fire case in Oklahoma will very likely have to deal with this important resolution.

Ignition & Combustion: Some Scientific Principles

by Vyto Babrauskas

Definitions

In order to properly understand fire, first some terms must be defined and discussed.

Fire. Fire is defined[7] as "Uncontrolled combustion." Controlled combustion takes place in an appliance such as a furnace, burner, etc.; by contrast, uncontrolled combustion does not take place in an appliance made for this purpose. Uncontrolled combustion also includes situations where appliances are intended for combustion, but malfunction, and combustion is not of the intended nature, for example, flame rollout from a gas-fired water heater.

Combustion. Combustion is defined7 as "A self-sustained, high-temperature oxidation reaction." Note that combustion does not require that flames be present. Non-flaming combustion includes glowing and smoldering combustion.

Oxidation. This is a chemistry term which has had a history of change. Originally, it simply meant reaction of a substance with oxygen. But eventually the concept became expanded, so that current-day chemistry defines it as "A chemical reaction in which a compound or a radical loses electrons." The opposite reaction, in which electrons are gained, is called 'reduction.' But for one compound to gain an electron, another must lose one, so both proceed simultaneously and the overall process is referred to as 'redox reactions.'

Flame. A rapid, self-sustaining propagation of a localized combustion zone at subsonic velocities through a gaseous medium. Flames are typically blue, yellow, orange, or red. With certain materials, however, flames can range from nearly-invisible to bright colors of a wide variety.

Ignition. Ignition is simply the initiation of combustion.

Pyrolysis. The chemical degradation of a substance by the action of heat. In fire science, sometimes *pyrolysis* is used to refer to a stage of fire before flaming combustion has occurred. In gas chromatography, *pyrolysis* is sometimes restricted to the heating of a substance without oxygen, but in fire science no implications of presence or absence of oxygen are made. A liquid that has changed color or appearance due to heating has demonstrably undergone pyrolysis, but sometimes chemical changes can take place without a clear change in appearance. Pyrolysis also pertains to solids, not just liquids. Of solids, the most relevant is wood. Despite improper usage by some investigators and even some Courts, pyrolysis does not signify ignition.

Wood and most other solids cannot ignite unless they have pyrolyzed. This can be demonstrated by heating a small stick of wood. It has to discolor and turn dark before ignition is possible. But the converse is not necessarily true. A piece of wood which has pyrolyzed so much as to turn into a black char may still never have reached the right conditions for ignition.

Flash point, piloted ignition, autoignition, and hot surface ignition. The flash point of a liquid is the minimum temperature at which the liquid gives off sufficient vapor to form an ignitable mixture with air near the surface of the liquid or within the test vessel used. The term is generally not used for solids, although it would not be incorrect to do so. Piloted ignition is the ignition of combustible gases or vapors by a secondary source of energy, e.g., a flame, spark, electrical arc or glowing wire. Autoignition is defined as initiation of combustion by heat but without a spark or flame. Spontaneous ignition is sometimes used as a synonym for autoignition, but this should be discouraged, since it creates confusion with spontaneous combustion, which is a different concept.

Hot surface ignition is ignition made possible by the hot surface of a solid, e.g., an electric stove heating element. Assuming the same substance was measured under comparable conditions, the four temperatures listed will always form a series flash point < piloted ignition temperature < autoignition temperature < hot surface ignition temperature.

Hot surfaces are particularly inefficient as a source of ignition, and the hot surface ignition temperature may be 200ºC than the autoignition temperature (AIT). Extensive compilations of values of ignition temperature values are available in the *Ignition Handbook*[7].

Pyrolysis of Fuels

Except for the simplest hydrocarbon fuels that merely need to evaporate to produce molecules simple enough to combine directly with oxygen in a flame, all fuels have molecules that have to be broken into small enough "pieces" to undergo combustion. The primary effect of heat on wood or other solid fuel is to decompose or pyrolyze the solid mass.

The words pyrolyze or pyrolysis stem from the Greek words pyro (meaning fire) and lysis (meaning decompose or decay). Therefore, pyrolysis can be defined as the decomposition of a material into simpler compounds brought about by heat. Pyrolysis of wood, for example, yields burnable gases such as methane; volatile liquids such as methanol (methyl alcohol) in the form of vapors; combustible oils and resins, and a great deal of water vapor; leaving behind a charred residue, which is primarily carbon or charcoal. The gases and vapors generated diffuse into the surrounding air, and can form a flammable mixture that can ignite and burn.

Most solids do not burn as a solid material, nor do liquids ignite and burn as liquids. The only way that burning of them can take place is that the solid or liquid material pyrolyzes or vaporizes, and then it is these vapors which actually burn. Liquids commonly vaporize rather than pyrolyze, that is, the molecules simply go from liquid phase to vapor phase and are not broken down into smaller pieces. Note, however, that overheated oil which produces a foul odor is actually breaking down, not just vaporizing.

The term 'pyrolysis' is defined slightly different in chemistry, versus in fire safety science. In chemistry, pyrolysis is defined as the "degradation of a material due to heat, in the absence of oxygen." In fire safety science, however, pyrolysis is defined as "the chemical degradation of a substance by the action of heat." Thus, the crucial distinction is that, in fire safety science, pyrolysis may take place in presence of oxygen (and usually does). When chemists need to invoke this concept, they refer to 'oxidative pyrolysis.'

The chemistry of pyrolysis is highly complex, with several hundred compounds being produced by wood, for example, when it is heated enough to burn. Most other fuels show similar behaviors. Fortunately, it is normally not necessary to study the chemical details of the pyrolysis reactions in order to comprehend the burning of fuels.

While most solids must be pyrolyzed to burn, an exception is the elements. Since, by definition, an element is the simplest chemical substance, it will not be broken down into pieces. The elements that can burn are commonly metals such as aluminum or titanium. But *charcoal* is mostly an element—carbon—with smaller proportion of hydrogen and various other elements. The combustion of elements (and charcoal) is different from the combustion of wood, paper, plastics, and most of the other common fuels. Elements burn primarily by glowing combustion. In this type of combustion, chemical reactions occur directly at the surface, resulting in a glow being seen. Flames will not be seen, if the reactions take place only at surface of the fuel. Burning charcoal sometimes does show a faint blue flame outside the surface of burning charcoal, since carbon tends to be oxidized to CO at the surface and the CO combustion product is a gas which can get further oxidized to CO_2 in the gas phase. If there is a lot of hydrogen or impurities in the charcoal, then a yellow flame may also be seen.

Chemical Reactions

In general, chemical reactions can either absorb or give off energy. Reactions that absorb energy are called endothermic reactions. Reactions that give off energy are called exothermic reactions, and the overall effect of combustion must manifest as an exothermic reaction.

Chemical reactions in combustion are actually exceedingly complex and dozens of individual 'elementary' reactions are involved that together comprise the combustion process. Reaction rates increase with increasing temperature, so the energy given off in an exothermic reaction can increase the reaction rate, resulting in the release of even more energy.

To have a fire requires the fire triangle be met. Air's presence is generally expected. In kitchen fires, the fuel is likely to initially be grease or cooking oil, but may progress to burning wood or other building components.

[7] Babrauskas, V., Ignition Handbook, Fire Science Publishers/Society of Fire Protection Engineers, Issaquah WA (2003).

In addition, after the "uncontrolled" fire is ignited, 'chain reactions' take place which allow the combustion process to continue. Due to this fact, in modern usage the fire triangle concept is expanded to a 'fire tetrahedron,' where a fourth leg comprising 'propagating chain reactions' is specified to be necessary.

A fire will not exist, if any of the four legs of the fire tetrahedron are removed. Consequently, a fire can be extinguished by: (a) burning the fuel out, or (b) putting foam on it (keeps oxygen out), or (c) pouring water on it (removes heat), or (d) applying some specific chemicals such as Halon 1301 which interfere with the chain reaction process and, thus, extinguish the fire.

Temperatures of Flames and Fires

Before discussing details of flame temperatures, it is important to distinguish between some of the major flame types. Flames can be divided into four categories:

- laminar, premixed
- laminar, diffusion
- turbulent, premixed
- turbulent, diffusion

An example of a laminar premixed flame is a gas burner flame. Laminar means that the flow streamlines are smooth and do not bounce around significantly. Two photos taken a few seconds apart will show nearly identical images. Premixed means that the fuel and the oxidizer are already mixed before the combustion zone occurs. A laminar diffusion flame example is a candle. The fuel comes from the wax vapor, while the oxidizer is air; they do not mix before being introduced (by diffusion) into the flame zone. Most turbulent premixed flames are from engineered combustion systems: boilers, furnaces, etc. In such systems, the air and the fuel are premixed in some burner device. Since the flames are turbulent, two sequential photos would show a greatly different flame shape and location. Most unwanted fires fall into the category of turbulent diffusion flames. Since no burner or other mechanical device exists for mixing fuel and air, the flames are diffusion type. Table 1 shows some typical values of peak temperatures that may be expected.

Table 1 Some Typical Flame Temperatures

Flame type	Typical peak temperature (ºC)
laminar premixed	depends on burner design
laminar diffusion	1400
turbulent premixed	1100 – 1300
turbulent diffusion	900 – 1100

In a serious building fire, peak temperatures at typically on the order of 1000ºC, in rare cases reaching 1200ºC. At the other end of the scale, flames do not go below about 300 – 500ºC (with most experimental studies favoring the higher number). Any temperatures measured below roughly such a minimum will be found to be in places where flaming is not present. The same temperatures hold true irrespective of whether the fire is natural or gasoline was poured all over the place. In the latter case, what will differ is the rate of fire spread and the fraction of the building undergoing high temperatures at a particular moment.

Adiabatic Flame Temperature

When one consults combustion textbooks for the topic of 'flame temperature,' what one normally finds are tabulations of the adiabatic flame temperature. 'Adiabatic' means without losing heat. Thus, these temperatures would be achieved in a (fictional) combustion system where there were no losses. Even though real-world combustion systems are not adiabatic, the reason why such tabulations are convenient is because these temperatures can be computed from fundamental thermochemical considerations: a fire experiment is not necessary. For methane burning in air, the adiabatic flame temperature is 1949°C, while for propane it is 1977°C, for example. The value for wood is nearly identical to that for propane. The adiabatic flame temperatures for most common organic substances burned in air are, in fact, nearly indistinguishable. These temperatures are vastly higher than what any thermocouple inserted into a building fire will register!

Measuring Flame Temperatures

Care must be exercised in making flame temperature measurements if useful results are to be obtained.

The most common error is using a too-thick thermocouple, in which case values will be reported that are much lower than appropriate. To get reliable values, thermocouple wire diameter should ideally be 0.005", but certainly no larger than 0.010". If thick thermocouples are used, values will be reported which are many hundreds of degrees lower than expected.

Temperatures of Objects

It is common to find that investigators assume that an object next to a flame of a certain temperature will also be of that same temperature. This is, of course, untrue. If a flame is exchanging heat with an object which was initially at room temperature, it will take a finite amount of time for that object to rise to a temperature which is 'close' to that of the flame. Exactly how long it will take for it to rise to a certain value is the subject for the study of heat transfer. Here, it is sufficient to point out that the rate at which target objects heat up is largely governed by their thermal conductivity, density, and size. Small, low-density, low-conductivity objects will heat up much faster than massive, heavy-weight ones.

Ignition Temperature

Individuals not well versed with fire safety science are likely to believe that combustible substances possess an ignition temperature which is tabulated in handbooks in a way similar to boiling points, heats of combustion, or other quantities likely to show up in handbooks of chemistry or physics. This is not correct.

By ignition temperature, it is meant the temperature which the front surface of a material must be brought to, in order for ignition to occur. While in any given situation if ignition occurs obviously there has to be a measurable temperature at which this happened, nonetheless combustion science theories indicate that this temperature is in no way a constant of the substance and will, in fact, depend on various conditions, for example, the rate at which the specimen is being heated.

However, practical experiments indicate that, under certain conditions, the range of variation is not great and consequently one can then sensibly, if somewhat imprecisely, assign an ignition temperature to the substance.

Compilations of such data can be found in the *Ignition Handbook*[7] and other reference sources. Empirical studies further show that, if this is done, two different ignition temperatures need to be reported, the autoignition temperature (AIT) and the piloted ignition temperature. A *piloted ignition temperature* refers to conditions where a gas flame pilot, an electric spark, or some other localized source of high temperature exists to help initiate the combustion process. If no such localized high temperature exists, then the process is termed *autoignition* and a higher temperature must be reached by the specimen before flames will appear over its surface.

Apart from plastics, the other category of solids which is of major interest in understanding fires is wood and related materials. Substances such as plywood, particleboard, paper, and cardboard are also all made from wood and, while they may have adhesives, colorants, and other substances added, they are chemically still mostly wood and have combustion properties that reflect that. Wood is a bit different from plastics in that the ignition temperature has some unique properties. Unlike plastics, the ignition temperature is quite dependent on the heat flux imposed, in other words, how rapidly the material is being heated up. If a wood material is heated at the lowest possible heat flux under which it is possible to achieve ignition, then it ignites at approximately 250ºC, and initially always ignites in a glowing mode. Thus, there is no difference between the autoignition and the piloted ignition temperature for wood being heated at a low heat flux, since the presence of a pilot flame would only help to get a flame spread over the surface of the specimen, but the specimen ignites in a glowing mode and cannot achieve a flame unless heated more strongly. If wood is ignited at these minimum-feasible conditions and kept with only this amount of heating applied, it will tend to never erupt into flaming and continue just to glow.

If a higher heat flux is applied, then the material will initially start glowing, then later on transition to flaming. Whereas if a high heat flux is applied, then there is no glowing and the specimen ignites only into a flaming mode.

But a fascinating and perhaps unintuitive thing also happens—as the heat flux applied to the specimen is raised, the required surface temperature for ignition to be achieved also rises. For heat fluxes corresponding to those encountered from small or medium ignition sources (for example, a small burning wastebasket), hardwoods require about 300 – 310ºC for piloted ignition, while softwoods require 350 – 365ºC.

These numbers are not a misprint, and it indeed is slightly easier to ignite hardwoods than softwoods, which is due to different proportions of their chemical constituents. Data for autoignition at higher heat fluxes is scarce, but values may be on the order of 100ºC higher than for piloted ignition.

The above results only apply to short-term heating of wood. If the heat flux applied is in the range of those obtained from real, small ignition sources and not related to studies aimed at finding behavior at extremely low heat fluxes, then the ignition will occur within minutes, say on the order of 3 to 20 minutes. At the lowest possible heat flux, the process may take a few hours, for example, 3.5 h in the case of one set of experiments.[8] What happens with longer duration heating is very important, however, and is considered in the next section.

Smoldering Combustion

Smoldering can be defined as a propagating, self-sustained exothermic reaction wave deriving its principal heat from heterogeneous oxidation of a solid fuel[7]. This technical meaning is much narrower and more specific than the layman's view of smoldering. The layman often applies 'smoldering' to fires which show small (as opposed to larger) flames, or to situations where an external heat source is charring or pyrolyzing a substance.

Most combustible solids do not smolder. Generally, smoldering is only common with porous or granular materials that can char and that have limited, if any, tendencies to melt. In addition, the char structure must be porous and not clogged by molten material.

A very wide variety of organic substances can smolder when arranged into a layer of dust or powder.

In restaurants and other commercial establishments, perhaps the most common smolderable material which might be involved in fire is cellulosic attic insulation. In the U.S., this material is required by CPSC regulations to be treated with fire-retardant agents so as to resist smoldering. However, various studies have been reported where the insulation was either removed from existing buildings and tested, or else tested after a period of storage for a number of years[7], and these tests often gave a failing result for various reasons.

Consequently, if a fire enters an attic where cellulose insulation was installed, firefighting may be very difficult and perhaps unsuccessful. In addition, experience suggests that there may be more rekindle fires associated with cellulosic insulation than with any other single category of building material. Lightweight insulation boards or sheathing boards made from cellulosic fibers also tend to be readily ignitable in a smolder mode, but such boards do not tend to propagate fire as vigorously as cellulosic attic insulation.

In general, there is no smoke or odor emitted from a smoldering process until the smolder front is quite close to breaking through to an exposed surface (or transition to flaming occurs). As one study[9] documented: "There was no apparent sign of smoldering until several minutes before upward smoldering reached the top surface." Porous, smolderable material, in fact, serves as a very good filter medium, filtering out odor and soot particles.

Transition from Smoldering to Flaming Ignition

The question when, smoldering will transition to flaming combustion can be of great practical interest. Smoldering to flaming transition can occur in conditions where the material sits in stagnant air, but it is often found that a modest wind or draft makes the process faster, while a very high wind speed may reduce the propensity. In actual fires, as contrasted to experiments, however, it may be impossible to establish anything concrete about air flow velocities. But it is of practical importance to note that smoldering materials are often found to break out into flaming when the smolder front encounters a change of media; for example, smoldering cellulose loose-fill insulation tends to break out in flaming when the smolder front reaches a wood framing member[7].

Spontaneous Combustion and the Long-Term, Low-Temperature Heating of Wood

If wood is subjected to long-term heat exposure, it may ignite at temperatures much lower than found during short-term tests. For short-term testing, an ignition temperature of 250ºC is found using the ASTM D 1929 test procedure. But for long-term exposure, ignition can occur if the hot object is as low as 77ºC. There is a probability aspect to this, however.

[8] Gratkowski, M. T., Dembsey, N. A., and Beyler, C. L., Radiant Smoldering Ignition of Plywood, *Fire Safety J.* **41**, 427-443 (2006).

[9] He, F., and Behrendt, F., Experimental Investigation of Natural Smoldering of Char Granules in a Packed Bed, *Fire Safety J.* **46**, 406-413 (2011).

Thus, applying say 80 – 90ºC for months-to-years length worth of exposure will create a risk of fire, but not many structures will burn down, whereas applying 150ºC or 200ºC will create a much higher probability of fire. Under prolonged heating, ignition can occur at much lower temperatures due to self-heating, which is chemically a very similar process to that which occurs when the linseed-oil-soaked cloths spontaneously combust.

Lacking a laboratory based theory or model, the phenomenon had to be analyzed in the same way that scientific studies are always done in the first stage of the development of systematic knowledge—as a compilation of studies of case histories. Underwriters Laboratories Inc. reported a comprehensive study of this kind in 1959. In that study, Matson, Dufour, and Breen[10] concluded that such fires will not occur if temperatures are not allowed to rise above "90ºF above room temperature (approximately 80ºF) normally prevailing in habitable spaces." This establishes 170ºF (77ºC) as a value above which an overt possibility of fire may be experienced, although, as stated above, at this temperature the probability of ignition would be low. A recent study in the peer-reviewed scientific literature evaluated additional newer data and concluded that the UL-recommended temperature limit is still the correct one.[11] This 170ºF (77ºC) recommended limit was accepted in several codes, and should be followed even if the pertinent code or regulation does not explicitly contain such instructions.

In view of these above, from a designer's or installer's point of view, no installation should be made where wood materials will be subjected to long term heating by devices presenting heated surfaces of 77ºC or higher. A thin layer of steel not only will not help in such cases, but may actually be deleterious[12]. For the danger to exist, the heating has to be persistent over months-to-years, but it does not have to be continuous. Cycled heat exposures appear to be every bit as problematic as steady-state ones. It should be noted that even though UL produced the original research, not all of the current-day UL standards adhere to the 77ºC criterion. Thus, it remains the responsibility of a designer or installer to make certain that wood materials are not endangered by devices operating at excessive temperatures.

Long-term, low-temperature heating of wood typically involves one of three categories of heat sources: (a) steam pipes, or in some cases, hot water pipes running at higher than normal temperatures; (b) flues, chimneys, vents, and similar heating-related equipment; and (c) heat-producing equipment, e.g., burners, boilers, space heaters, etc. which are installed in proximity to wood surfaces. These sources of elevated temperatures are slightly different in terms of analyzing the events. Steam pipes and fixed heat-producing equipment will typically have peak temperatures which can be readily measured and measured. Flues and chimneys, on the other hand, may undergo great fluctuations in temperature due to damper settings, burner settings, creosote build-up, and other factors. Thus, with these devices it is normally less a question of measuring temperatures than it is of scrupulously following the manufacturer's instructions for installation.

The char that is produced during long-term heating is sometimes referred to as 'pyrophoric carbon,' although the term is scientifically questionable. It is also incorrect to say that such fires occurred due to 'pyrolysis.' Pyrolysis is the necessary prerequisite for the ignition of a solid material, but it does not explain anything and certainly does not identify the cause or the responsibility. When fires of this nature occur, the correct terminology is that they occurred due to long-term, low-temperature heating of wood, with the temperature necessarily being above 77ºC.

It is essential to understand that there is no such thing as an 'ignition temperature,' when low-temperature, long-term heating takes place. This is true not only for wood, but for any other materials susceptible to self-heating.

The value of 77ºC discussed above is thus not referred to as an 'ignition temperature,' but as the '*critical ambient temperature*' (CAT) needed for ignition. This terminology makes clear that there are other factors which enter into consideration, not just the identity of the substance.

[10] Matson, A. F., Dufour, R. E., and Breen, J. F., Survey of Available Information on Ignition of Wood Exposed to Moderately Elevated Temperatures, Part II of "Performance of Type B Gas Vents for Gas-Fired Appliances" (Bull. of Research 51), Underwriters' Laboratories, Inc., Chicago (1959).

[11] Babrauskas, V., Gray, B. F., and Janssens, M. L., Prudent Practices for the Design and Installation of Heat-Producing Devices near Wood Materials, *Fire & Materials* **31**, 125-135 (2007).

[12] DeHaan, J. D., and Icove, D. J., Kirk's Fire Investigation, 7th ed., Brady/Prentice-Hall, Upper Saddle River NJ (2012).

Other Spontaneous Combustion Possibilities

In commercial kitchens, apart from improperly installed flues or ducts next to wood members, the other situation where spontaneous combustion might be encountered, in fact, usually involves oil-soaked cloth items. Cooking oils are not as prone to self-heating as are some other types of oils (e.g., linseed oil or Tung oil). Nonetheless, they are prone to self-heating and spontaneous combustion fires do occur. Most typically, they occur in laundry facilities where oil-soaked towels, aprons, etc., are laundered. But they also have been known to occur in kitchens themselves, if for some reason a stack of such contaminated items is left in a pile, and especially if this is a place that is especially warm, say next to a baking oven. All such oils are perfectly safe when they are stored in the can, since the oil there is in bulk and oxygen cannot react with the material, except at the top surface. The problems only arise when the oil is dispersed into a cloth (or similar material), since then there comes to be a greatly increased contact between oxygen and oil.

Steam pipes, piles of oil-soaked fabrics, and any other situations which result in spontaneous combustion always proceed in two stages. The first stage of ignition is a smoldering ignition. If smoldering ignition is self-sustained, that already constitutes spontaneous combustion. Typically, however, after a certain time in a smoldering condition, fire progresses to flaming combustion. Once flaming breaks out, fire progression may be rapid, and significant losses may occur, if fire suppression in good working order is not available to extinguish the fire.

In must be noted that sprinklers and most other forms of suppression systems cannot detect or respond to a smoldering fire; thus there can be no expectation that even if a fully competent system exists, it would respond prior to flaming occurring. It unfortunately is not rare that the design of a sprinkler system omits protection in exactly the places where the fire may break out—within concealed spaces.

Ignition of Substances in Commercial Kitchens

A huge variety of ignitable liquids[13] exists. However, in commercial kitchens the liquids of most interest are cooking oils. In general, the differences between types of oils are effectively nonexistent, taken from the *Ignition Handbook*[7]. Unlike some simple liquids, cooking oils pyrolyze when heated strongly. Thus, overheating of oils may sometimes also be detected by smell, although quantitative guidance on this point cannot be given. It can be seen in the Table that where data from more than one source are available, the values are sometimes not close, which can reflect differences in both the oils and the measuring environment. It also can be seen that oils which have gone through a number of heating cycles generally show a poorer performance. Five categories of values are listed in the Table: flash point, fire point, AIT, and hot-surface ignition temperature.

- *Smoke point* is the lowest temperature at which the liquid proceeds to visibly smoke. Visible smoke means that molecules are already being broken up due to the heating, i.e., pyrolyzed, and pyrolysis is discussed below. If an alert individual is present, they should be able to observe smoking once the smoke point is reached and lower the heat, but sometimes that does not happen. It may still be quite a climb in temperature after the smoke point is reached before autoignition occurs.
- *Flash point* is the lowest temperature at which the liquid gives off sufficient vapor to show a flash, if a small pilot flame is presented; it is not required to continue burning under those conditions, just show a brief flash.
- *Fire point* is the lowest temperature at which a liquid in an open container will give off sufficient vapors to burn in a sustained manner once ignited; it generally is slightly above the flash point.
- The *AIT* is the lowest temperature at which a liquid in a closed container will ignite and burn, in the absence of a pilot flame or other localized source of heat.

[13] 'Ignitable liquids' is a term intended to encompass both flammable liquids and combustible liquids. The latter distinction has no meaning in science, but is a concept found in many codes and governmental regulations, where the authorities desire to distinguish between liquids of higher or lower fire hazard, with 'flammable' being defined as more hazardous than 'combustible.' In many countries, the definition is that flammable liquids are those with a closed-cup flash point below 60.5ºC, while combustible ones have flash points above 60.5ºC. This definition comes from the United Nations and, in the U.S., is adopted by the Dept. of Transportation. Formerly, DOT and NFPA used definitions where 38.5ºC (101ºF) was the dividing line. The latter value originated in the late 19th century, where a safety campaign for "100ºF kerosene" was the motivating factor. In that era, specifications for kerosene were not standardized, and some serious fires were occurring when kerosene with a flash point below ambient room temperature was being used.

- The *hot surface ignition temperature* will vary greatly according to the details of the test apparatus (of which none are standardized) but it denotes a condition where either vapors or droplets of a liquid come into contact with a hot surface of limited size.

The hot surface ignition temperature testing environment differs from the test environment for AIT testing, where droplets of the liquid are dropped into a closed heated flask. The hot surface ignition temperature is always significantly higher than the AIT, since in the case of the AIT test the vapors are captured inside a flask which is all at the elevated temperature, while in a hot-surface ignition test, the vapors can escape (since the environment is not closed), and furthermore not the whole perimeter of the volume is raised to the elevated temperature. Hot surface ignition tests run with different experimental apparatuses will produce varying results, due to variations in the degree of 'enclosedness.' As a rule of thumb, it is sometimes estimated that the hot surface ignition temperature = AIT + 200ºC, but any such rule can only be a rough approximation.

A question that will be asked, in the commercial kitchen fire is what temperature category will correspond to an actual incident? The flash point can be easily dismissed, since it corresponds to a temperature where only a flash occurs and the burning then stops. If this were the case in real life, the fire department would not be called, nor would the fire be investigated. The fire point will correspond to the temperature needed for the oil to reach so that if it is spilled and ignited on a gas flame, the oil keeps burning instead of the flame stopping.

Table 1 Properties of cooking oils

Fat	Smoke point (ºC)		Flash point (ºC)		Fire point (ºC)	AIT (ºC)		Hot surface ignition temp. (ºC)	
	N	U	N	U	U	N	U	N	U
canola oil	154					431			
	224-230		275-290			365-372			
			321			405			
coconut oil			294			360			
corn oil	173	121	254	227	321	309	283	526	542
	220		321						
drippings	179	157	254	241	331	348	276	553	537
hydrogenated cooking fat	214	135	260	210	331	355	273	568	554
lard	186	134	249	218	326	355	282	541	568
olive oil		159	234	218	316	340	280	562	543
	130		225			436			
peanut oil	151	152	260	243	335	342	280	552	535
	232								
sesame oil			336			419			
			255						
soybean oil	160					406			
			320			400			

N = virgin; U = after 8 heating cycles

More common in a serious fire, is the scenario where the oil is not spilled, but ignites due to overheating. What category of temperature is needed to describe that? Direct experiments have not been done comparing overheated oil in woks or other cooking utensils with arrangements used in fire tests. But it is most likely that the value corresponds rather closely to the AIT. In probably the majority of the incidents, a lid will not be used, thus the utensil is open on top and the oil vapors are leaving directly at that locale.

By contrast, in the AIT test, any packet has nowhere to go (since the flask is capped and at a uniform temperature) and can thus ignite at a lower temperature. In the wok cooking incident, vapors are leaving rapidly, but as they leave, they are replaced by vapors which are identically as hot (since the whole liquid contents of the wok are at the same hot temperature, and there is no other, hotter temperature involved in the system). Thus, it can anticipated that the overheated wok will ignite when the liquid temperature reaches the AIT.

Investigation for Subrogation

By Thomas Wolfe

Introduction

In cases involving the potential for property subrogation, the most common scenario is that of fire, water or other damage caused either by a defective product or someone's negligence. A substantial number of these involved fire. In contrast to an automobile claim, the investigation and determination of cause is difficult in a fire because of the considerable destruction, which often occurs, and the frequent lack of eyewitnesses to the initiating event.

In most cases, an independent origin and cause investigation is made by both a private investigator and the public fire marshal. If a product is involved, a forensic engineer, chemist, or other scientist may be engaged, not only to examine the remains in the laboratory, but also to view the scene before removal. As the facts unfold, other experts may be engaged to examine the possibility of liability against a particular third party.

An optimal investigation is one that is conducted as soon as practical after the loss so that the scene is untouched and the evidence preserved. However, this can become burdensome on the adjuster, whose primary concern is to adjust the claim in a timely manner.

Fire Marshal's Investigation of the Scene

As a general rule, state statute empowers and directs the fire marshal to investigate the cause, origin and extent of loss of all fires occurring within the jurisdiction.

These statutes give the fire marshal the power at all times of the day and night to enter upon and examine any building or premises where any fire has occurred and any other buildings or premises adjoining or near thereto. The fire marshal is also vested with police powers in making the investigation.

In general, and with the exception of large or unique fires, once the fire marshal determines that the cause is accidental, his investigation stops. This is due primarily to considerations of time and expense, as well as the generality of the directive in the statute. This highlights the need for copious and timely private cause and origin investigation.

Notwithstanding this, the fire marshal's role as a witness in the case can be crucial. That is because he is generally independent from any party and his testimony is most often given the greatest weight by the trier of fact. Accordingly, when he determines a fire to be accidental, he is encouraged to be as specific as possible as to the cause of the fire, and to eliminate other potential accidental causes so that a single cause can be pinpointed.

The most desired situation is to leave the scene unaffected for future investigators. However, practices of post-fire cleanup vary among fire departments. Clearly, the modern trend is to avoid cleanup whenever practical in order to keep the scene intact.

The fire marshal is also encouraged to secure the scene to prevent entry by unauthorized persons and to communicate as best as possible with the victim and/or the insurance carrier to make sure that the scene and evidence are preserved. Unfortunately, many fire marshals take the position that once their investigation has been concluded, their obligation to preserve the scene ceases.

With respect to possible testimony to be rendered in the future, the fire marshal is advised to save all his notes in addition to making a report and taking photographs, so that there can be the optimal possibility of refreshing his recollection of the investigation a number of years later.

Independent Investigation of the Scene

Although hired by a particular party to investigate the fire, the primary investigator is independent, and he should therefore conduct his investigation independently of other investigators and without a preconceived notion of what he will find or conclude. Private fire investigators can generally be classified in two categories, although the lines between them are sometimes difficult to draw. There is the origin and cause investigator. He is someone who is trained to examine a fire scene and determine the point of origin and cause of the fire.

Many origin and cause experts are ex-fire department investigators trained both on-the-job and through fire investigation courses offered locally and at the national level. Others are professional engineers. A number of states now have a certification for fire investigators.

The other type of investigator is a specialist in some particular field, such as electricity, chemistry, metallurgy, etc. Besides examining evidence taken from the fire scene in his lab, this type of investigator will often go to the scene in order to view such evidence prior to alteration or removal. In fact, many times it is advisable to require the specialist, rather than the cause and origin investigator, to undertake the responsibility of removing the evidence from the scene and documenting same.

It is often the case when counsel is not involved that the investigator or other expert will be asked to render a written report after conducting his examination and coming to a conclusion. Caution is advised with the making of a report, however, because it is most often discoverable when the witness is identified as an expert to testify at trial. Given also that facts many times change as new information is revealed, the making of a report may limit the expert because of the basis upon which he has opined.

Other Experts

In addition to those experts who are called upon to investigate the origin and cause of fire, other persons might be consulted related other issues. The most common of these involve fire spread.

In many jurisdictions, in order to obtain joint and several liability against a defendant, all persons and entities responsible for the loss, including its extent, must be joined in the action. Thus, it is not uncommon for questions to be asked, such as whether the appropriate fire walls and fire stops were in place, or whether particular building product burned as it should have in the fire, or whether the fire sprinkler system operated properly.

Other questions might be the response time of the fire department, although there is often an immunity or an adherence to the legal principle that there is no specific duty owed to the property owner by the public fire authority in these circumstances. In any event, serious consideration would obviously need to also be given evaluating the performance of the fire department in light of sentiment created by the events of September 11th.

Role of Insurance Adjuster

While the primary duty of the adjuster is to adjust the loss of the insured, a viable subrogation case cannot be built without efforts of the adjuster in both arranging for the private investigators and making sure the scene remains intact.

In some respects, the insurance adjuster plays a pivotal role in securing the scene for future investigation. It is he who deals with the fire marshal, the private experts and the insured, and it is he who can act as liaison between those persons to make sure the scene is unaffected prior to investigation. It is also the adjuster who has the opportunity to call in the independent investigators as early on as possible, so that hopefully, reconstruction of the premises can be initiated without delay.

It is all too often that the fire marshal claims that his job is limited to determination of cause and extent of loss, and it is not his job to secure the fire scene after the fire department is through. Good early coordination with the insured or property owner at the conclusion of the fire department's investigation precludes the possibility that the scene will be altered or tampered with.

Notification of Third-Party Tort-Feasors

An argument which has arisen with more and more frequency is that the defendant has been prejudiced because the scene and/or evidence has been altered or lost prior to its having had an opportunity to investigate. This is commonly referred to as the spoliation defense.

Depending upon the facts and circumstances, as a sanction, the court could dismiss the case, exclude the testimony of plaintiff's experts, or it could give an adverse instruction to the jury related to the "spoliated" evidence.

If the subrogation investigation you have conducted reveals the likelihood of a viable subrogation case against a particular defendant, it is advisable to put the defendant on notice of the loss prior to the scene and/or evidence being altered or affected.

This not only helps the potential for recovery by having the defendant thinking about the case early on, it also precludes the argument at a later date that the defendant did not have an opportunity to investigate and is therefore at a disadvantage in terms of determining other potential causes of the loss.

The foregoing means that the scene of the loss must be preserved after notice for a reasonable period of time. What is a reasonable period is determined on a case-by-case basis in light of all of the facts and circumstances.

Investigation of the Product Related Fire

It is helpful to understand the primary issues involved in a product liability case in investigating a fire where the suspected cause may be product related. The laws involving product liability vary widely from state to state. Simply stated, the product defect could be one of design, manufacture, breach of expressed or implied warranty, or a failure to instruct or warn.

The age of the product is often important because there exist statutes of repose or similar features which limit the claimant's right to bring a product liability action, depending upon the product's age and the consumer's reasonable expectation as to the period of time the product would be expected to be used safely.

Product liability law, as it has evolved in the United States, imposes liability upon all persons in the distribution chain for injury caused by the defective product. Recent tort reform in some states, however, has excepted the wholesaler and retailer from liability where they have done nothing inappropriate (no negligence, no misrepresentation, etc.) and there is a manufacturer available to process against whom a judgment can be satisfied.

The liability of the manufacturer is also sometimes imposed upon the retailer or wholesaler who has a special relationship to the manufacturer, such as where the retailer or wholesaler provided the plans or specifications for the manufacture, and such plans or specifications were a proximate cause of the defect; the retailer or the wholesaler is a controlled subsidiary of the manufacturer, or vice versa; or the product was marketed under the trade name or brand name of the retailer or wholesaler.

Because of the substantial devastation that occurs at the fire scene, a product suspected of causing a fire may be damaged to an extent, which precludes determination of a specific defect even with the most detailed examination. Certain case law may be helpful. In these cases, the product is alleged to have caused the fire, but is virtually impossible to identify any malfunctioning part as the most probable cause. Expert witnesses called by the plaintiff identify the product as the cause of the fire, and they have eliminated all other potential sources. Some courts have held that, under these circumstances, the trier of fact is permitted to infer that the product was defective because common experience indicates that the fire would not have occurred in the absence of a defect in the product.

Conclusion

If choreographed properly, investigation of the fire scene can yield the potential for a viable case involving third party negligence or product liability. However, by the same token, if the investigation is not conducted properly at the outset, the likelihood for success in the pursuit of a third party civil action is diminished substantially.

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Covering Issues Applicable To Subrogation For Damages Caused By Third Part Negligence And System/Product Failure

Excerpts From Scientific Protocols for Fire Investigation

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From Fire Dynamics -- Fire and Energy

Chemical reactions either absorb energy or give it off. Reactions that absorb energy are called endothermic. Reactions that give off energy are called exothermic. Reaction rates increase with increasing temperature, so the energy given off in an exothermic reaction can increase the reaction rate, resulting in the release of even more energy. This process can result in a phenomenon called "thermal runaway." Fire is an exothermic chemical reaction that gives off energy in the form of heat and light. It is this energy that makes fire useful or destructive. The understanding of fire requires a grasp of the basic concepts of energy.

Such a grasp may seem more elusive as we examine the concept more closely. The first concept that must be addressed is the distinction between energy and temperature. When matter absorbs energy, its temperature increases. The molecules that make up a substance are constantly in motion. Increased temperature is manifested by an increase in molecular motion or molecular vibration.

If the air in a car's tires is hotter, the molecules of oxygen and nitrogen are moving faster, colliding with the walls of the tire and increasing the pressure (The typical speed of an oxygen molecule at room temperature is about 480 meters per second or 1080 miles per hour.) The kinetic theory of gases, worked out by Maxwell and Boltzmann, states that the typical speed of a gas molecule is proportional to the square root of the temperature. An increase in temperature also results in solids melting, liquids vaporizing and molecular bond vibrations increasing. Given sufficient energy, these bonds will break, resulting in the formation of new, smaller molecules. **Temperature is the measurable effect of the absorption of energy by matter.**

Most of what is known about energy involves the transformation of energy from one form into another. For example, gasoline contains energy and when put in a car, it can be burned in the engine and used to move the vehicle. This process converts chemical energy to heat energy, and heat energy into mechanical energy. The power company burns coal to boil water to move a turbine that spins a magnet inside a coil of wires to produce electrical energy. When that electrical energy is passed through a filament to make light, or through a resistance element to heat water or air, it is turned into heat energy. When it is supplied to a motor, the electrical energy is converted into mechanical energy.

It is useful to think of energy as the ability to do work. Count Rumford learned from his experiments with friction that the work of boring a cannon barrel produced heat energy, which he used to boil water. It was his insight that heat is actually a form of work that allowed for the understanding of the concepts of energy transfer.

If a glass of ice water is placed in a room, heat will flow from the room into the glass until the ice melts. Eventually, the water will be the same temperature as the room, and heat transfer will cease. Energy transfer that takes place by virtue of a temperature difference exclusively is called a "heat flow." It was this concept of "flow" that led early chemists to the caloric theory—something was flowing. While Lavoisier and others thought it was a substance that was flowing, Rumford and Joule proved that it was energy.

The unit of work in any system of measurement is the unit of force multiplied by the unit of distance. In the metric system, the unit of force is the newton, and the unit of distance is the meter. A newton is that force which gives one kilogram an acceleration of one meter per second per second. One newton-meter equals one joule, which is the basic unit of energy. The English equivalent of the newton-meter is the foot-pound (its equivalence to the newton-meter would be more apparent if it were called the "pound-foot"). Although the pound is used in everyday life as a unit of quantity of matter, properly speaking, it is a unit of force or weight. Thus, a pound of butter is that quantity that has a weight of one pound. The foot-pound is a unit of work equal to the work done by lifting a mass of one pound (0.454 kilograms) vertically against gravity (9.8 meters per second per second) through a distance of one foot (0.305 meters). Doing just a little math (0.454 X 9.8 X 0.305), or consulting any good conversion table, reveals that one foot-pound equals 1.356 joules.

But what can movement of a weight over a distance tell us about heat transfer? The work involved in moving a standard weight over a standard distance has been determined to be equivalent to raising the temperature of a body of water by a fixed number of degrees. The "calorie" was originally defined as the amount of energy required to raise the temperature of one gram of water one degree Celsius. As the quantitative measurement of heat transfer became more precise, it was discovered that it takes more energy to raise the temperature of a gram of water from 90ºC to 91ºC than it does to raise it from 30ºC to 31ºC. This variability required that the definition be refined, and the calorie is now known as the "15º calorie," that is, the quantity of heat required to change the temperature of one gram of water from 14.5º C to 15.5º C. A corresponding unit, defined in terms of degrees Fahrenheit and pounds of water, is the British thermal unit, or Btu.[14] One Btu is the quantity of heat required to raise the temperature of one pound of water from 63ºF to 64ºF (17.222^{o} to 17.777^{o} C). Since the quantity of water is greater (454 grams), and the temperature increase is less, (0.555^{o} C), one Btu equals 252 calories (454 X 0.555=252).

We have discussed the equivalence of work and heat, but relating this concept to our everyday experience requires that we consider an important dimension that has, thus far, been left out: time.

The amount of work required to raise a given weight to a given height is the same, whether it takes a second, a minute, or an hour. Likewise, the amount of heat necessary to raise the temperature of a gram of water from 14.5ºC to 15.5ºC is the same, regardless of how long it takes (assuming a perfectly insulated system).

[14] To honor great scientists, we name units of measure after them, but do not capitalize the name of the unit. The abbreviation for a unit named after a person is capitalized, as is the B for "British" in British thermal unit. The temperature scales are always capitalized, whether written out or abbreviated.

The amount of work done per unit time is the quantity of interest. The rate at which work is done is called "power," and is defined as the work done divided by the time interval. Appliances that use energy are defined by the power that they produce, either in Btus/hour or in watts. A watt is one joule per second. The time component is built in. When the energy consumption or energy output is reported as Btus, the time element needs to be added. The size of a fire can be described in terms of watts, or more commonly, kilowatts or megawatts. The fire investigator who has the ability to relate the energy output of a fire to everyday heating and cooking appliances is well on the way to understanding, and being able to explain the phenomenon of fire.

A fire investigator needs to understand and be able to describe ignition sources and fires in terms of their size in watts. Consider a controlled fire, the natural gas burner in a 40,000 Btu/hour water heater. Most people have a rough idea of the size of that flame. What is its output in watts? The watt, as a unit of energy, already contains a time factor, as one watt equals one joule per second. The energy output of gas appliances is usually expressed as "Btus," but that is shorthand for "Btus per hour."

1 Btu = 1054.8 joules.

1 watt = 1 joule/second.

40,000 Btu/hour = 11.11 Btu/second.

11.11 X 1054.8 joules/second = 11,720 watts or 11.72 kilowatts.

A 12,000 Btu stovetop burner delivers about 3,500 watts.

12,000 Btu/hr = 3.33 Btu/sec

3.33 Btu/sec X 1054.8 joules/watt = 3,516 watts.

A 125,000 Btu gas furnace delivers 36,625 watts.

What the power company sells is actually not power (watts), but energy (joules). The meter measures energy consumption in kilowatt-hours (kWh). A kilowatt is a thousand joules per second. A kilowatt-hour equals a thousand joules per second times 3,600 seconds per hour, or 3.6 million joules, or 3,413 Btus. Table 2.1 gives some useful energy and power conversion factors.

The size of a fire in kilowatts is known as its *heat release rate* or HRR. The HRR is the single most important property of a fire, because it allows us to predict how that fire will behave, and to relate the fire to our everyday experience. The heat release rate affects the temperature of the fire, its ability to entrain air (draw fresh air into the fire plume), and the identity of the chemical species produced in the fire. The size of a fire, or any energy source, is important to know, but it is equally important to know how that energy is distributed. Thirty-six kilowatts spread evenly throughout a structure by a furnace's circulation fan will keep it comfortable on a cold winter day. Confining or focusing that energy can result in dramatically different consequences. The concept of *radiant heat flux* is therefore an important consideration. Heat flux is a measure of the rate of energy falling on or flowing through a surface. The radiant heat flux from a fire is a measure of the heat release rate of a fire in kilowatts, multiplied by the radiant fraction (about 0.3), divided by the area over which the energy is spread in square meters. Radiant heat flux is measured in units of power per unit area, or kilowatts per square meter. (Some texts have used the CGS[15] system and reported radiant heat flux in watts per square centimeter. There are 10,000 square centimeters [100 x 100] in a square meter, and 1,000 watts in a kilowatt, so 20 kilowatts/square meter equals 2 watts/square centimeter.)

The noonday sun bathes the earth with a radiant heat flux of approximately 1.4 kilowatts/square meter (kW/m^2), and about 0.7 to 1 kW/m^2 makes it to the earth's surface, depending on the time and location. This is enough energy to cause a sunburn in thirty minutes or less. We cannot increase the heat release rate of the sun, but we can increase the radiant heat flux by focusing the energy that falls on a large area onto a smaller area. If we use a magnifying glass or a concave mirror to decrease the area by 96 per cent, the radiant heat flux shoots up to 25 kW/m^2, enough to ignite most combustibles, as shown in Figure 2.2. Figure 2.3(a) shows how sunlight focused by a concave makeup mirror burned one stripe per day into the underside of the soffit outside the window where the mirror was located. Figure 2.3(b) shows a similar fire, caused by sunlight being focused through a "bubble window," popular in the UK.

Thirty seconds of exposure to a 4.5 kilowatt/square meter radiant heat source can cause a second-degree burn. Twenty kilowatts per square meter is largely accepted as the radiant heat flux required to bring an average residential compartment to flashover. Therefore, if flashover has been reached in a compartment, one can calculate the minimum heat release rate of the fire in that compartment by multiplying the area in square meters by 20 kilowatts. A square room twelve feet on a side will flash over if the fire inside releases 267 kilowatts. (144 square feet equals 13.37 square meters, times 20 kilowatts per square meter equals 267 kilowatts.)

15 CGS means "centimeter/gram/second" opposed to MKS, which means "meter/kilogram/second.

Keep in mind, however, that fires typically release their energy as conduction and convection as well as radiation. The radiation may only account for 20 to 60% of the energy, and less than half of that reaches the floor. In addition, energy is lost to the walls and ceilings, and there are convective losses out of any openings in the enclosure. Therefore, in order to get 267 kW on the floor, the fire must be approximately 800 kW or more. Likewise, if the heat release rate of the fuel in the room is known, one can predict whether a fire on a particular fuel package is sufficient to bring the room to flashover. Table 2.2 describes the effects of some typical radiant heat fluxes.

Table 2.1 Energy Conversion Factors

Energy, work, or quantity of heat	
1 joule (J)	1 newton meter (N·m)
	0.7376 foot-pounds (ft-lb)
	9.48 X 10^{-4} Btu
	2.778 X 10^{-4} watt-hr
	10^7 erg
1 kilojoule (kJ)	1000 N·m
	737.6 ft-lb
	0.948 Btu
	0.2778 watt-hr
	10^{10} erg
1 kilowatt-hr (kWh)	3.6 X 10^6 J
	3,600 kJ
	3,413 Btu
	2.655 X 10^6 ft-lb
1 British thermal unit (Btu)	1054.8 J
	2.928 X 10^{-4} kilowatt-hr
	252 gram-calories

Power or radiant heat flux	
1 watt (W)	1 Joule/sec
	10^7 ergs/sec
	3.4129 Btu/hr
	0.05692 Btu/min
	1.341 X 10^{-3} horsepower (hp)
1 kilowatt (kW)	1 kJ/sec
	10^{10} ergs/sec
	3413 Btu/hr
	56.92 Btu/min
	0.9523 Btu/sec
	1341 hp
1 Btu/hr	0.2931 W
	0.2162 ft-lb/sec
1000 Btu/hr	2931 W
	2.931 kW
1000 Btu/sec	1050 kW
1 horsepower (hp)	745.7 W
	0.7457 kW
	42.44 Btu/min
	2546.4 Btu/hr

Table 2.2 Typical Radiant Heat Fluxes

Approximate Radiant Heat Flux (kW/m^2)	Comment or Observed Effect
170	Maximum heat flux as currently measured in a post flashover fire compartment.
80	Heat flux for protective clothing Thermal Protective Performance (TPP) Test.[a]
52	Fiberboard ignites spontaneously after 5 seconds.[b]
29	Wood ignites spontaneously after prolonged exposure.[b]
20	Heat flux on a residential family room floor at the beginning of flashover.[c]
16	Human skin experiences sudden pain and blisters after 5-second exposure with second-degree burn injury.[a]
12.5	Wood volatiles ignite with intended exposure[d] and piloted ignition.
10.4	Human skin experiences pain with 3-second exposure and blisters in 9 seconds with second-degree burn injury.[a,b]
6.4	Human skin experiences pain with a second exposure and blisters in 18 seconds with second-degree burn injury.[a,b]
2.5	Common thermal radiation exposure while firefighting.[f] This energy level may cause burn injuries with prolonged exposure.
1.4	Thermal radiation from the sun. Potential sunburn in 30 minutes or less.[g]

Source: NFPA 921, *Guide for Fire and Explosion Investigations, with permission.*

Note: The unit kW/m^2 defines the amount of heat energy or flux that strikes a known surface area of an object. The unit (kW) represents 1000 watts of energy and the unit (m^2) represents the surface area of a square measuring 1 m long and 1 m wide. For example, 1.4 kW/m^2 represents 1.4 multiplied by 1000 and equals 1400 watts of energy. This surface area may be that of the human skin or any other material.

Sources: [a]From NFPA 1971, *Standard on Protective Ensemble for Structural Fire Fighting.* [b]From Lawson, “Fire and the Atomic Bomb.” [c]From Fang and Breese, “Fire Development in Residential Basement Rooms.” [d]From Lawson and Simms, “The Ignition of Wood by Radiation,” pp. 288-292. [e]From Tan, “Flare System Design Simplified,” pp. 172-176. [f]From U.S. Fire Administration, “Minimum Standards on Structural Fire Fighting Protective Clothing and Equipment.” [g]From Bennett and Myers, *Momentum, Heat, and Mass Transfer.*

Avoiding Spoliation [16]

It is now necessary to interrupt the flow of this discussion in order to discuss an issue that ever more frequently interrupts the flow of fire investigations. Spoliation is defined as the "loss, destruction or material alteration of an object or document that is evidence or potential evidence in a legal proceeding by one who has the responsibility for its preservation."[17] There often comes a time that an investigator realizes that a particular device may have malfunctioned and caused the fire. This may be a light switch or a ceiling fan or a cooking or heating appliance, a computer, or any one of thousands of manufactured products. It may be that a contractor performing a service, such as refinishing the floor or re-roofing a commercial building, was on site shortly before the fire, and the evidence seems to point to some careless act on the part of one of the contractor's employees. When this occurs, it is the investigator's job to stop any further activity that might prejudice the rights of an entity that may soon become a party to litigation. The investigation can resume at a later time. If the property is insured, the insurance carrier will look to whoever caused the fire for compensation. That party, in turn, will likely insist on the opportunity to view the evidence. Failure to accommodate potential defendants may result in sanctions against the plaintiff seeking damages, up to and including dismissal of the lawsuit.

Spoliation has so far not been an issue in criminal cases, but it is likely to come up in the future, so the concept should not be dismissed out of hand by arson investigators.

In one Minnesota case, *Tollefson*,[18] the Court dismissed an arson charge because the fire scene was demolished shortly before the defendant was indicted.

To avoid spoliation, potential defendants must be put "on notice," be told when the investigation will proceed, and allowed to send a representative to participate in the continuation of the investigation. The investigator should communicate with the client about the preliminary determination, and either the client (usually an insurance company or a lawyer representing an insurance company) or the investigator contacts the manufacturer, contractor or other potential defendant to give them the bad news.

The time required for the potentially responsible party to engage its own investigator, and for that investigator to make arrangements to come to the scene makes it necessary to cease operations and come back another day. Since bringing in other parties may involve considerable expense to those entities, once the investigator determines that a joint inspection of the scene is required, careful consideration should be given to finding all of the potentially responsible parties. This is necessary because if it turns out that the first party notified is able to demonstrate, for example, that it was not their coffeemaker that started the fire, but the microwave oven next to it, it then becomes necessary to put the manufacturer of the microwave oven on notice, and reconvene the investigation at a later date.

Such complications can result in a fire scene inspection stretching out for several days over a period of months. Sometimes, it just makes sense to notify any party that may be responsible, and let them decide whether to participate in the investigation. Some manufacturers have dollar criteria, below which they will not send an investigator. Others will respond to notification by asking that everything be documented and their product be preserved for later laboratory examination. If a potentially responsible party is notified, but chooses not to participate in the investigation, that party will not later be able to make a successful claim of spoliation.

Spoliation is a relatively new concept for many investigators. In the past, an investigator would go to the site, determine the cause, and if that cause was an appliance, it would be collected and taken to an electrical engineer for further evaluation. If the engineer found evidence that the appliance was responsible for the fire, the insurance carrier would make a claim against the manufacturer, and the case would proceed. Such behavior by a fire investigator in the twenty-first century, however, will not only prevent the investigator's client from collecting from the manufacturer of the defective product, it is likely to get the investigator sued, even if he has correctly identified the cause of the fire and it is, in fact, defective.

Spoliation has become the second line of defense in product liability litigation.[19] This is possibly a result of the legal community becoming aware of a relatively high rate of error (see Chapter 9) in the determination of origin and cause of fires. Defendants no longer simply accept the first determination, and the courts have supported their position.

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[16] The pronunciation of this word is frequently mangled. The correct pronunciation is spo-lee-AY-shun.

[17] NFPA 921, 2004, Section 13.

[18] *State of Minnesota, Appellant, v. Gary Bruce Tollefson, Respondent,* No. C9-91-283, Court of Appeals of Minnesota, 1991 Minn. App. LEXIS 737, July 17, 1991.

[19] After paternity.

Not only is it necessary to let the manufacturer see its defective product, it is often necessary to **let them see it in place**, to let them have their own investigator confirm that the product was, in fact, at the origin of the fire, and to allow that investigator to independently rule out other potential sources of ignition. A manufacturer of clothes dryers, defending itself in a product liability action, will likely be successful if the washing machine was not at least preserved for inspection by the manufacturer's chosen investigator. A coffee maker manufacturer may claim spoliation if their investigator was not allowed to see the kitchen range before it was sent to the landfill, even if there is clear evidence of overheating on the element.

Claims of spoliation can be taken to ridiculous extremes, and realizing this, NFPA's Technical Committee on Fire Investigations has undertaken to offer guidance not only on what activities constitute spoliation, but also on those activities that should **not** be considered spoliation. It is usually necessary to conduct significant debris removal prior to uncovering the cause of the fire.[20]

Debris removal to uncover the area of origin should not be considered spoliation. Nor should removal of the offending device from the scene be considered spoliation, if such removal is necessary to either protect the device, or to identify its manufacturer. Further, it may be possible to eliminate an appliance by a simple nondestructive examination off-site. Note that any device once suspected but later eliminated needs to be preserved so that it can be examined by other potentially responsible parties.

The destruction of an "innocent" coffee maker (or failure to preserve it) may result in the failure of a claim against, for example, a tenant who left a pan of food cooking on the range.

Scenarios such as this one may influence criminal cases as well. It is no longer acceptable for a public sector investigator to "eliminate" a reasonable potential source of accidental ignition, and then allow it to be destroyed. A defendant may then claim that he has been prejudiced by the destruction of potentially exculpatory evidence. Such a claim will be especially effective if the only "evidence" of an incendiary cause is the investigator's inability to find any source of accidental ignition in the area identified as the origin.

Claims of spoliation seeking monetary damages from public agencies for destroying evidence are not common, but public sector investigators should not dismiss the idea of preserving evidence for the civil investigation. Running over a fire scene with a bobcat or a backhoe to look for "pour patterns" or spalling, particularly if no such "evidence" is uncovered, makes it next to impossible for the real cause of the fire to be discovered.

Must Fire Investigators Prepare a Written Investigation Report?

Excerpt from Dennis Smith's NFPA Article[21]

In a word, No. Not every fire investigation requires a written report. In fact, the decision to write one depends not on the requirements of NFPA 1033, Fire Investigator Professional Qualifications, as people frequently assume, but on the jurisdiction, the responsibility of the investigator, the purpose of the investigation, the client's desires, and the policy and practices of the employer. There's no requirement in NFPA 1033 to prepare a written report during an actual investigation or to perform any of the tasks listed in the standard.

Rather, NFPA 1033 lays out the job performance requirements (JPRs) that an individual must be able to do, not necessarily what he or she is required to do, identifying the duties, tasks, knowledge, skills, and performance evaluation criteria for the position of fire investigator in both the private and public sectors. While NFPA 1033 is not a training document in of itself, the "Requisite Knowledge and Skills" statements are used to develop the terminal training objectives for lesson plans and curricula. The scope, their purpose, and an explanation of JPRs are found in Chapter 1, "Administration," which clearly indicates that JPRs define what the investigator "must be able to perform in order to successfully carry out that duty."

[20] It is almost axiomatic that the debris is always deepest at the origin. Also, if it is raining on the day of the inspection, the roof will be most completely destroyed directly over the origin.

[21] Dennis W. Smith in the NFPA Journal, May/June 2005 (pg 65)

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Appendix A – References

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- E 620 Standard Practice for Reporting Opinions of Technical Experts
- E 678 Standard Practice for Evaluation of Technical Data
- E 860 Standard Practice for Examining and Testing Items that are or may Become Involved in Products Litigation
- E 1188 Standard Practice for Collection and Preservation of Information and Physical Items by a Technical Investigator

B.1 List of Abbreviations

AGA American Gas Association	NFPA National Fire Protection Association
AHJ Authority Having Jurisdiction	NICET National Institute for Certification in Engineering Technologies
AIA American Institute of Architects	NOAA National Oceanic and Atmospheric Administration
APCU Air Pollution Control Unit	NSF National Sanitation Foundation
ASHRAE American Society of Heating Refrigerating and Air Conditioning Engineers, Inc.	NTSB National Transportation Safety Board
AWG American Wire Gauge	OSHA Occupational Safety and Health Administration
BOCA Building Officials and Code Administrators Association	PPB Parts Per Billion
CFM Cubic Feet per Minute	PPM Parts Per Million
CKV Commercial Kitchen Ventilation	PSI Pounds per Square Inch
CMM Cubic Meters per Minute	PWNA Power Washers of North America
CSA Canadian Standards Association	SBCCI Southern Building Code Congress International
EMT Electrical Metal Tubing	SMACNA Sheet Metal and Air Conditioning Contractors National Associations
EPA Environmental Protection Agency	TQC Trained, Qualified and Certified
ESP Electro Static Precipitator	UFC Uniform Fire Code
GPM Gallons Per Minute	UL Underwriters Laboratories, Inc.
HVAC Heating Ventilation and Air Conditioning	ULC Underwriters Laboratories of Canada
IBC International Building Code	UMC Uniform Mechanical Code
ICBO International Conference of Building Officials	USDA United States Department of Agriculture
ICC International Code Council	WCB Workers Compensation Board
IHS Industrial Health and Safety	WHMIS Workplace Hazardous Material Information System
IKECA International Kitchen Exhaust Cleaning Association	
IMC International Mechanic Code	
MSDS Material Safety Data Sheet	
N/A Not Available	
N/I No Information	

C.1 Definitions

In addition to these definitions, also see NFPA Terms.

ABRASION: Wearing or rubbing away by friction.

ACCELERANT: A fuel (usually a flammable liquid) that is used to initiate or increase the intensity or speed of spread of fire.

ACCESS PANEL: A closure device (door or hatchway) used to cover an opening into a duct, an enclosure, equipment or an appurtenance (including access to fans, etc.).

ACCESS: 1) Attaining reach to components, i.e.; being able to reach (fans, etc.). 2) Gaining entry into systems (ducts, etc.).

ACCIDENT: Unplanned or unintentional event; an event occurring without design or intent.

ADIABATIC: Condition of equilibrium of temperature and pressure.

ADSORPTION: Trapping of gaseous materials on the surface of a solid substrate.

AEROSOL: A dispersion of solid or liquid particles in gas or air (i.e. smoke, fog).

AFTER-SERVICE FOLLOW UP REPORT: Reports drafted by service workers to customers after job is completed.

AHJ: Authority Having Jurisdiction; The organization, office or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure. (e.g.: City Hall; Fire Dept., etc.).

AIR INTAKES: Generally, an opening to a building to allow outside air in; to replace exhausted air.

AIR MOVEMENT: In this context; the physics of air circulation(s) within, and exhausted from, buildings.

AIR POLLUTION CONTROL DEVICES: Equipment and devices used for the purpose of cleaning air passing through them or by them in such manner as to reduce or remove the impurities contained therein.

AIR QUALITY: The measurement of the proportions of contaminants and other particulates in the air within buildings.

AIR STREAM: In this context; the air that is mechanically exhausted from buildings.

ALLIGATORING: Rectangular patterns of char formed on burned wood.

ALTERED COOKING OILS: Fat renderings, also including food particles, moisture, and dirt.

AMBIENT: Surrounding conditions.

ANNEALING: Loss of temper in metal caused by heating.

APPLIANCE: A device or instrument, esp. electrical for (household or kitchen) applications. Equipment, usually nonindustrial, that is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, cooking, etc. Normally built in standardized sizes and types, i.e. gas, electric or solid-fuel cooking equipment applications.

APPLIANCE FLUE OUTLET: The opening or openings in a cooking device where vapors, combustion gases, or both leave the cooking device.

APPROVED: Acceptable to the authority having jurisdiction.

APPURTENANCE: An accessory or a subordinate part that enables the primary device to perform or improve its intended function.

ARC: Flow of current across an air gap between two conductors.

AREA OF ORIGIN: The room or area where a fire began.

ARSON: The intentional setting of a fire with intent to damage or defraud.

ARRESTANCY EFFICIENCY: The ability of a filter or grease-removal device to retard airflow and capture grease-laden vapor.

ASHRAE: American Society of Heating, Refrigerating, Air-conditioning Engineers, Inc. (See Introduction Section)

ATOM: Smallest unit of an element that still retains its properties.

ATOMIZE: To reduce to minute particles or a fine spray.

AUTHORITY HAVING JURISDICTION: (NFPA Def.) The organization, office, or individual responsible for approving equipment, and installation, or a procedure.

AUTO-IGNITION: Ignition of combustion by surrounding temperature in the absence of an external source of ignition (without a spark or flame); non-piloted ignition.

AUTO-IGNITION TEMPERATURE: The temperature at which a material will ignite in the absence of any external pilot source of heat; spontaneous ignition temperature.

AUTOIGNITION: Initiation of combustion by heat, without a spark or flame.

BACKDRAFT: A deflagrative explosion of gases and smoke from an established fire that has depleted the oxygen content of a structure, most often initiated by introducing oxygen through ventilation or structural failure.

BACKSHELF HOOD: Low-level hood, relatively close to cooking surface-upon which plates, etc., can be placed for warming.

BAFFLE: (also baffle plate) An object placed in or near an appliance to change the direction of, or to retard the flow of air or gas.

BAFFLE PLATE: An object placed in or near an appliance to change the direction of, or to retard the flow of, air or gas.

BID SHEET: An estimate or cost sheet used to analyze and propose costs of cleaning to customers.

BIODEGRADABLE: A substance capable of natural decomposition into harmless elements in a short (7 day) period.

BIO-HAZARDOUS: Dangerous or poisonous to living organisms-especially people.

BLEVE: Boiling-liquid, expanding-vapor explosion. A mechanical explosion caused by the heating of a liquid in a sealed vessel to a temperature far above its boiling point.

BOILING POINT: The (pressure-dependent) temperature at which a liquid changes to its gas phase.

BOLTED DUCT: See “DUCT”; Glossary.

BRANCH CIRCUIT: The circuit conductors between the outlet(s) and the final overcurrent device protecting that circuit.

BRITISH THERMAL UNIT (BTU): The quantity of heat required to raise the temperature of one pound of water 1ºF at the pressure of 1 atmosphere and temperature of 60ºF, a British thermal unit is equal to 1055 joules, 1.055 kilojoules, and 252.15 calories.

BTU: British thermal unit. A standardized measure of heat, it is the heat energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

CALCINATION: Loss of water of crystallization caused by heating.

CANOPY (style hood): (also OVERHEAD) Hoods hung over cooking line, usually close to ceiling.

CAPTURE MATS: A protective matting used to either clean equipment on or to catch waste water.

CAUSE: The circumstances, conditions, or agencies that brought about or resulted in the fire or explosion incident, damage to property resulting from the fire or explosion incident, or bodily injury or loss of life resulting from the fire or explosion incident.

CAUSTIC: Agent that burns or destroys organic tissue by chemical action. Capable of corroding or eating away tissues, burning, corrosive.

CEILING JET: A relatively thin layer of flowing hot gases that develops under a horizontal surface (e.g., ceiling) as a result of plume impingement and the flowing gas being forced to move horizontally.

CELLULOSIC: Material based on a polymer of natural sugars (plant-based materials).

CENTRIFUGAL FORCE: (Physics) The inertial reaction by which a body tends to move away from the center of rotation.

CERTIFICATION: The issuance by an authorized (by legislation) body of a certificate to a person or company acknowledging the attainment of specified criteria.

CERTIFIED: A formally stated recognition and approval of an acceptable level of competency, acceptable to the AHJ.

CFM/CMM: (In air movement) Cubic feet per minute or Cubic meters per minute.

CHAR: Carbonaceous remains of burned organic materials.

CHARBROILER: Cooking appliance utilizing open flame (fueled by gas, elec. or solids), with an iron grid system, mainly for cooking steaks (beef, fish, etc.).

CHROMATOGRAPHY: Chemical procedure that allows the separation of compounds based on differences in their chemical affinities for two materials in different physical states, i.e. gas/liquid, liquid/solid.

CIRCUIT BREAKER: A device designed to open a circuit automatically at a predetermined overcurrent without injury to itself when properly applied within its ratings.

CLEAN BURN: An area of wall or ceiling where the charred organic residues have been burned away by direct flame contact.

CLEANING/CLEAN: (In this context) Removal of grease and cooking residues from Kitchen Exhaust Systems to the point where surfaces are clearly visible.

COLLOIDS: A substance, whether gas, liquid or solid, dispersed in a continuous gas liquid or solid medium. The particles, consisting of very large molecules or large aggregates of molecules, do not settle (or do so very slowly).

COMBUSTIBLE: Capable of burning, generally in air under normal conditions of ambient temperature and pressure, unless otherwise specified; combustion can occur in cases where an oxidizer other than oxygen in the air is present (e.g., chlorine, fluorine, or chemicals containing oxygen in their structure.)

COMBUSTIBLE CONSTRUCTION – CLOSED: Combustible building construction including walls, structural framing, roofs, roof ceilings, floors, and floor-ceiling assemblies continuously enclosing a grease duct on four sides where one or more sides are protected.

COMBUSTIBLE CONSTRUCTION – OPEN: Combustible building construction including wall, structural framing, roof, roof ceiling, floor, and floor-ceiling assemblies adjacent to a grease duct on three or fewer sides where one or more sides are protected.

COMBUSTIBLE LIQUID: A liquid having a flash point at or above 37.8ºC (100ºF).

COMBUSTIBLES/COMBUSTIBLE MATERIAL: Material made of, or surfaced with, wood, compressed paper, plant fibers, plastics or other material that will ignite & burn whether flame-proofed or not, or whether plastered or not.

COMBUSTION: (As used herein) The rapid oxidation of fuel accompanied by the production of heat or heat & light.

COMBUSTION PRODUCTS: Effluent (heat, gases, solid particulates, liquid aerosols) resulting from the combustion of fuel including the inerts but excluding excess air.

CONCEALED SPACE: That portion(s) of a building behind walls, over suspended ceilings, in pipe chases, attics, and in whose size might normally range from 44.45 mm (1 ¾ in.) stud spaces to 2.44 m (8ft) interstitial truss spaces and that might contain combustible materials such as building structural members, thermal and/or electrical insulation, and ducting.

CONCEALED WIRING: Wiring rendered inaccessible by the structure or finish of the building. Wiring in covered raceways is considered concealed.

CONDENSE: (Physics) The restoration to liquid form of (from a) gas or vapor.

CONDITIONED AIR: The air that is purified and has had its temperature and humidity are regulated before it enters a room or building.

CONDUCTION: Heat transfer to another body or within a body by direct contact.

CONDUCTOR: Any material capable of permitting the flow of electrons: (1) bare -a conductor having no covering or electrical insulation whatsoever; (2) covered -a conductor encased within a material whose composition or thickness is not considered insulative; (3) insulated -a conductor encased within a material recognized by the electrical code as insulation.

CONDUIT: A channel or pipe for containing liquids, cables, electrical wiring, etc.

CONFINED SPACE: 1) (OSHA); A space must meet the following criteria: large enough and configured so that a person can bodily enter & perform assigned work, there is limited or restricted means for entry or exit (e.g. tanks, vaults), not designed for continuous person occupancy. Under this definition, an empty fuel tank or, in some cases, certain rooms could qualify. Or it can simply mean a duct. 2) (As used here in) any cramped, tight work area.

CONTAMINANTS: Made impure, polluted, admixtured.

CONTINUOUS ENCLOSURE: A recognized architectural or mechanical component of a building having a fire resistance rating as required for the structure and whore purpose is to enclose the vapor removal duct for its full length to its termination point outside the structure without any portion of the enclosure having a fire resistance rating less than the required value.

CONTINUOUS WELD: (NFPA Def.): A metal joining method without visible interruption or variation in quality. For the purpose of the definition, it specifically includes the exhaust compartment of hoods and welded joints of exhaust ducts, yet specifically does not include filter support frames or appendages inside hoods. Welding is a fabrication technique for joining metals by heating the materials to the point that they melt and flow together to form an uninterrupted surface of no less strength than the original materials.

CONTROL CABINET: (As used here in) a cabinet, usually stainless steel, housing controls for ventilators, or fire-extinguishing system control.

CONTROLLED MATERIALS: Chemicals and substances regulated by legislation.

CONVECTION (also, C-ovens): (Physics) The transference of heat or the circulation thereof in gases and liquids.

COOKING LINE: Assembled (major) cooking appliances, arranged in a straight line, under hoods.

COOKING BATTERY/LINE: Assembled (major) cooking appliances, arranged in a straight line, under hoods.

COOKING EQUIPMENT: Appliances used in the cooking.

COOKING SURFACE: Surfaces on which food is heated and grease is transformed into a vaporous state.

CORPUS DELICTI: Literally, the body of the crime. The fundamental facts necessary to prove the commission of a crime.

COWLING: Covering or housing, esp. around fans.

CRAZING: Stress cracks in glass and the result of rapid cooling.

CSA: Canadian Standards Association, especially in electrical appliances.

DAMPER (NFPA Def.): A valve or plate within a duct or its terminal components for controlling draft or the flow of gases, including air.

DEAD LOAD: The weight of a structure and any equipment and appliances permanently attached.

DEDUCTIVE REASONING: The process by which conclusions are drawn by logical inference from given premises.

DEEP-SEATED: Fire that has gained headway and built sufficient heat in a structure to require great cooling for extinguishment; fire that has burrowed deep into combustible fuels (as opposed to a surface fire); deep charring of structural members.

DEFLAGRATION: A very rapid oxidation with the evolution of heat and light and the generation of a low-energy pressure wave that can accomplish damage. The reaction proceeds between fuel elements at subsonic speeds.

DETERGENT INJECTORS: Jets or nozzles which disperse cleaning soaps into ventilators.

DETONATION: An extremely rapid reaction that generates very high temperatures and an intense pressure/shock wave that produces violently disruptive effects. It propagates through the material at supersonic speeds.

DEVICE: Any chemical or mechanical contrivance or means to start a fire or explosion.

DIATOMIC: Molecules consisting of two atoms of an element.

DIFFUSION FLAME: A flame in which fuel and air mix or diffuse together at the region of combustion.

DIRECT ATTACK: Application of hose streams or other extinguishing agents directly on a fire, rather than attempting extinguishment by generating stream within a structure.

DRAPING: Covering cooking equipment with plastic during the cleaning process.

DROPDOWN: The collapse of burning material in a room that induces separate, low-level ignition; fall down.

DUCT: A continuous passageway for the transmission of air and vapors, in addition to the containment components themselves, might include duct fittings, dampers plenums, and/or other items or air-handling equipment. They may be round, square, bolted, solid, continuous weld.

DUCT -- GALVANIZED: A weatherproof zinc coating of steel. Emits poisonous gases when welded.

DUCT INTERIOR: The internal surfaces of exhaust ductwork where the grease accumulates.

DUCT TERMINATION: The final or intended end-portion of a duct system that is designed and functions to fulfill the obligations of the system in a satisfactory manner.

DUCT WRAP: An encapsulating system where a fire resistive material is used to cover the duct. Some products are listed for enclosure of grease ducts.

DUTY: Conditions of use in electrical service; (1) continuous duty--operation at substantially constant load for an indefinitely long time; (2) intermittent duty--operation for alternate intervals of (a)load/no load; (b)load/rest; or (c)load/no load/rest; (3) periodic duty--intermittent operation in which the load conditions are regularly recurrent; (4) short-time duty--operation at substantially constant load for a short and definitely specified time; (5) varying duty— operation at loads, and for intervals of time, both of which are subject to wide variation.

DWELL TIME: Period of time chemical will hang on a surface to penetrate the grease.

EASILY ACCESSIBLE (NFPA Def.): Within comfortable reach, with limited dependence on mechanical devices, extensions, or assistance.

EFFLUENT: An outflow; more commonly, waste or industrial sewage.

ELBOW: (As used herein) a turn, a joint or join, an angle or bend-especially in ducts.

ELECTRO-MECHANICAL: Fire dampers, which are activated by heat sensitive thermoswitches.

ENDOTHERMIC: Absorbing heat during a chemical reaction.

ENTRAIN: The mixing of two or more fluids as a result of laminar flow or movement.

ENTRANTS: Personnel working inside ductwork.

ENTRY PROGRAM: Compilation of policies & procedures for entrants working in confined spaces.

EUTECTIC: An alloy of two materials having special physical or chemical properties, typically having the lowest melting point of any combination of the two.

EVAPORATE: To assume the vapor state by a gradual physical change to which all solids and liquids are subject, at all temperatures.

EXHAUST: AIR: The air that is drawn out from the cooking area.

EXHAUST HOOD: colloquialism used by Kitchen Exhaust Cleaners to describe a range of metal canopies, which constitutes the bottom end of the Kitchen Exhaust Systems.

EXOTHERMIC: Generating or giving off heat during a chemical reaction.

EXPLOSION: The sudden conversion of potential energy (chemical or mechanical) into kinetic energy with the production of heat, gases, and mechanical pressure.

EXPLOSIVE: Any material that can undergo a sudden conversion of physical form to a gas with a release of energy.

EXPLOSIVE LIMITS (flammability limits): The lower and upper concentrations of an air/gas-or-vapor mixture in which combustion or deflagration will be supported.

EXPOSURE: Property that may be endangered by radiant heat from a fire in another structure or an outside fire. Generally, property within 40 feet is considered an exposure risk, but larger fires can endanger property much farther away.

EXTINGUISHER: See Fire-Extinguishing Systems.

FACTORY-BUILT GREASE DUCT ENCLOSURES: A listed factory-built grease duct system evaluated as an enclosure system for reduced clearances to combustibles and as an alternative to a duct with its fire-rated enclosure.

FANS: A term applied to electrical fans; machines fitted with blades that revolve rapidly about a central hub- the driving force behind Kitchen Exhaust Systems.

FASTENERS: (As used here in) screws and bolts, sometimes welded nipples or pins, used to attach access panels and the like.

FIELD-APPLIED GREASE DUCT ENCLOSURE: A listed system evaluated for reduced clearances to combustibles and as an alternative to a duct with its fire-rated enclosure.

FILTER – BAFFLE: A filter that acts as a barrier between the cooking surface and the duct which removes grease from the airstream by centrifugal force.

FILTER – GREASE: A removable component of the grease removal system designed to capture grease and direct it to a safe collection point.

FILTER – MESH: A filter that acts as a barrier between the cooking surface and the duct which removes grease from the airstream by impingement force.

FILTER – MODULAR EXTRACTOR OR DRY CARTRIDGE: A series of angular plates that act to create air resistance.

FIRE: A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities.

FIRE ANALYSIS: The process of determining the origin, cause, development, and responsibility as well as the failure analysis, of a fire or explosion.

FIRE BEHAVIOR: The manner in which a fuel ignites, flame develops, and fire spreads. Unusual fire behavior may reveal the presence of added fuel or accelerants.

FIRE CAUSE: The circumstances, conduction, or agencies that bring together a fuel, ignition source, and oxidizer (such as air or oxygen) resulting in a fire or a combustion explosion.

FIRE-EXTINGUISHING EQUIPMENT: Automatic fire-extinguishing systems and portable fire extinguishers provided for the protection of grease removal devices, hoods, duct systems, and cooking equipment, and listed for such use.

FIRE-EXTINGUISHING SYSTEMS: Extinguishers, conduit, controls, nozzles, etc. that are mounted in Kitchen Exhaust Systems in the event of fire.

FIRE INVESTIGATION: The process of determining the origin, cause, and development of a fire or explosion.

FIRE LOAD: The total amount of fuel that might be involved in a fire, as measured by the amount of heat that would evolve from its combustion (expressed in units of heat).

FIRE PATTERNS: The visible or measurable physical effects that remain after a fire.

FIRE POINT: The lowest temperature at which a liquid in an open container will give off sufficient vapors to burn once ignited. It generally is slightly above the flash point (NFPA 850).

FIRE PROTECTION: Fire safety systems and other proactive measures for diminishing fire risks.

FIRE RESISTANCE RATING: The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*.

FIRE-RESISTIVE: A structure or assembly of materials built to provide a predetermined degree of fire resistance as defined in building or fire prevention codes (calling for 1-, 2-, or 4-hour fire resistance).

FIRE TRIANGLE: Formula whereby oxygen, fuel and heat combine to produce fire. Removal of one or more components makes it impossible to sustain burning.

FIRE WALL: A solid wall of masonry or other non-combustible material capable of preventing passage of fire for a prescribed time (usually extends through the roof with parapets).

FLAME: A body or stream of gaseous material involved in the combustion process and emitting radiant energy at specific wavelength bands determined by the combustion chemistry of the fuel. In most cases, some portion of the emitted radiant energy is visible to the human eye.

FLAMEOVER: The flaming ignition of the hot gas layer in a developing compartment fire.

FLAME POINT: Temperature at which a flame is sustained by evaporation or pyrolysis of a fuel.

FLAME RESISTANT: Material or surface that does not maintain or propagate a flame once an outside source of flame has been removed.

FLAME SPREAD: The rate at which flames extend across the surface of a material (usually under specific conditions).

FLAMMABLE (same as inflammable): A combustible material that ignites easily, burns intensely, or has a rapid rate of flame spread. See “Combustible”, glossary.

FLAMMABLE LIMIT: The upper or lower concentration limit at a specified temperature and pressure of a flammable gas or a vapor of an ignitable liquid and air, expressed as a percentage of fuel by volume that can be ignited.

FLAMMABLE LIQUID: A liquid that has a closed-cup flash point that is below 37.8°C (100°F) and a maximum vapor pressure of 2068 mm Hg (40 psi) at 37.8°C (100°F).

FLANGE: A projecting rim or collar.

FLASH POINT OF A LIQUID: The lowest temperature of a liquid, as determined by specific laboratory tests, at which the liquid gives off vapors at a sufficient rate to support a momentary flame across its surface.

FLASHBACK: The ignition of a gas or vapor from an ignition source back to a fuel source (often seen with flammable liquids).

FLASHOVER: The final stage of the process of fire growth; when all combustible fuels within a compartment are ignited, the room is said to have undergone flashover.

FLANGE: A projecting rim or collar.

FPM: Feet Per Minute.

FRAGMENTATION: The fast-moving solid pieces created by an explosion. Primary fragmentation is that of the explosive container itself; secondary fragmentation is that of the target shattered by an explosion.

FREQUENCY: Intervals by which cleaning needs to be repeated.

FRYERS - DEEP FAT: A vat-like cooking appliance in which oil is heated to 191ºC (375ºF) as a medium for frying foods.

FRYERS - HIGH EFFICIENCY: A deep fat fryer with the ability to heat oil to temperatures near 316ºC (600ºF).

FUEL: A material that will maintain combustion under specified environmental conditions.

FUEL GAS: Natural gas, manufactured gas, LP-Gas, and similar gases commonly used for commercial or residential purposes such as heating, cooling, or cooking.

FUEL LOAD: All combustibles in a fire area, whether part of the structure, finish, or furnishings.

FULLY INVOLVED: The entire area of a fire building so involved with heat, smoke, and flame that entry is not possible until some measure of control has been obtained with hose stream attacks.

FUSIBLE LINK: A form of fixed temperature heat detecting device sometimes employed to restrain the operation of an electrical or mechanical control until its designed temperature is reached.

GALVANIZED: A weatherproof zinc coating of steel. Emits poisonous gases when welded.

GASKET: Normally, packing to make a joint leak-proof. For kitchen exhaust cleaners, it most often refers to the plating used to seal access panels.

GAUGE: A measure of the thickness of metal (and other products), e.g.: "18-gauge stainless steel". Also, a device to measure contents, e.g., fire-extinguishing system agent.

GHOST MARKS: Stained outlines of floor tiles produced by the dissolution and combustion of tile adhesive.

GLOWING COMBUSTION: The rapid oxidation of a solid fuel directly with atmospheric oxygen creating light and heat in the absence of flames.

GREASE (NFPA Def.): Rendered animal fat, vegetable shortening, and other such oily matter used for the purposes of and resulting from cooking and/or preparing foods. Grease might be liberated and entrained with exhaust air, or might be visible as a liquid or solid.

GREASE CONTAINMENT SYSTEM: A means to protect a roof from grease damage.

GREASE: DIRTY: a result of a greater number of particulates mixed together in grease compounds.

GREASE DUCT: A containment system for the transportation of air and grease vapors that is designed and installed to reduce the possibility of the accumulation of combustible condensation and the occurrence of damage if a fire occurs within the system.

GREASE FILTER: A component of the Kitchen Exhaust Systems that deflects air/vapors in a manner that allows for condensation on it-thus reducing particulates passing up the rest of the duct. (See FILTERS)

GREASE LADEN VAPOR: Atomized particles of 'grease' suspended along with water droplets, in the air-stream.

GREASE REMOVAL DEVICES: A system of components designed for and intended to process vapors, gases, and/or air as it is drawn through such devices by collecting the airborne grease particles and concentrating them for further action at some future time, leaving the exiting air with a lower amount of combustible matter.

GREASETIGHT: Constructed and performing in such a manner as not to permit the passage of any grease under normal cooking conditions.

GREASE TRAP: Settling chamber in plumbing through which kitchen effluent is drawn with the purpose of separating out grease which is disposed of periodically.

GRILL TOP: Flat, metal cooking surface for preparing foods such as pancakes, bacon, etc.

GROUND: A conducting connection, whether intentional or accidental, between an electrical circuit or equipment, and the earth, or to some conducting body that serves in place of the earth.

GROUND FAULT: An interruption of the normal ground return path of electricity in structure that leads to unintended current flows.

HEAT: A form of energy characterized by vibration of molecules and capable of initiating and supporting chemical changes and changes of state.

HEAT OF COMBUSTION: The quantity of heat released from a fuel during combustion measured in kJoules/g or Btu/lb.

HEAT FLUX: The measurement of the rate of heat transfer to a surface, expressed in kilowatts/m^2, kilojoules/$m^2 \cdot s$, or Btu/$ft^2 \cdot s$.

HEAT OF IGNITION: The heat energy that brings about ignition.

HEAT RELEASE RATE (HRR): The rate at which heat energy is generated by burning, usually measured in watts, joules/sec, or Btu/sec.

HEAT TRANSFER: Spread of thermal energy by convection, conduction, or radiation, high explosive. Any material designed to function by, and capable of detonation.

HOODS: A device provided for a cooking appliance(s) to direct and capture grease-laden vapors and exhaust gases.

HOUSING: Usually the collar or distal box-end, upon which the fan rests.

HVAC: Heating, Ventilation & Air Conditioning (units).

HYDROCARBON: Chemical compound containing only hydrogen and carbon.

IGNITABLE LIQUID: Classification for liquid fuels including both flammable and combustible classes.

IGNITION: The process of initiating self-sustaining combustion.

IGNITION ENERGY: The quantity of heat energy that should be absorbed by a substance to ignite and burn.

IGNITION TEMPERATURE: Minimum temperature a substance should attain in order to ignite under specific test conditions.

IMPINGEMENT FORCE: Blocking or striking force.

INCENDIARY FIRE: A deliberately set fire.

INCIPIENT: Beginning stages of a fire.

INDIRECT APPLICATION: A method of firefighting by applying water fog into heated atmospheres to obtain heat absorption and smothering action by generating steam.

INERTS: (Chemistry) Devoid of active properties.

INORGANIC: Containing elements other than carbon, oxygen, nitrogen, and hydrogen.

INSPECTION SHEET: Documentary tool used in Inspections.

INSPECTIONS: (As used herein) Examination of kitchen exhaust systems and fire extinguishing equipment to evaluate need for servicing and to assess deficiencies of same.

INTERNAL FIRE PROTECTION: An assembly of dampers and fire actuated water spray system generally used in water wash hoods.

JOULE: The preferred SI unit of heat, energy or work; there are 4.184 joules in a calorie, and 1055 joules in a British thermal unit (Btu). A watt is a joule/second.

K.E.C.: Kitchen Exhaust Cleaner. K.E.Cs. = Plural.

K.E.S.: Kitchen Exhaust System. K.E.Ss. = Plural.

LABELED: Equipment of materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

LIMITED-COMBUSTIBLE MATERIAL: Refers to a building construction material not complying with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu/lb. (8141 kj/kg), where tested in accordance with NFPA 259 and includes (1) materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 1/8 in. (3.2mm) that has a flame spread index not greater than 50; and (2) materials, in the form and thickness used, other than as described in (1), having neither a flame spread index greater than 25 nor evidence of continued progressive combustion, and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion.

LIQUIDTIGHT (NFPA Def.): Constructed and performing in such a manner as not to permit the passage of any liquid at any temperature.

LISTED: Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

LOCKOUT (PROCEDURE): Mandatory policies & procedures instituted by companies to save from harm (electrical shock, gas exposure, moving parts), employees when servicing kitchen exhaust systems.

MAKEUP AIR: Replacement air for a building's exhausted air-usually brought in from the outside; to equalize pressure.

MAKEUP AIR UNIT: Mechanical device designed to draw in make-up air.

MESH (FILTERS): Hood filters containing meshed metal fibers that trap grease. Because they become quickly occluded and hard to clean, they become a hazard in of themselves and have thus been outlawed in most jurisdictions.

MATERIAL FIRST IGNITED: The fuel that is first set on fire by the heat of ignition; to be meaningful, both a type of material and a form of material should be identified.

MICROWAVES (OVENS): Relatively new generation of cooking appliances that utilizes microwaves to excite molecules within food; thus heating them artificially.

MSDS: Material Safety Data Sheet. WHMIS designation for a universally recognized document that contains specific information about a product.

NFPA: National Fire Protection Association.

NON-FLAMMABLE: Material that will not burn under most conditions.

NORMAL HYDROCARBONS (n-hydrocarbons): Hydro-carbons having straight-chain structures with no side branching; aliphatics.

NOZZLES - FIRE-EXTINGUISHING SYSTEMS: Part of fire-extinguishing systems from which fire-extinguishing chemicals spray. (See Section 3-4.6)

NOZZLES - PRESSURE WASHER: The tip of the wand. These nozzles come in various angles and sizes.

NOZZLES - WASH: Part of the water wash system from which chemical and water are sprayed to clean the interior of the hood.

OLEFINIC: Hydrocarbons containing double carbon-carbon bonds (denoted C==C); non-saturated; alkenes.

OPEN WIRING: Un-insulated conductors or insulated conductors without grounded metallic sheaths or shields, installed above ground but not inside enclosures or appliances.

ORGANIC: Compounds based on carbon.

OSHA: Occupational Safety and Health Administration.

OUTLET: A point on the wiring system at which current is taken to supply equipment or appliances by means of receptacles or direct connections.

OVERHAUL: The firefighting operation of eliminating hidden flames, glowing embers, or sparks that may rekindle the fire, usually accompanied by the removal of structural contents.

OXIDIZING MATERIAL: (Chemistry) A chemical conversion involving a loss of electrons, i.e. material that has an affinity to combine with oxygen atoms to de-materialize, e.g. "rusting iron".

OZONOLYSIS: A reaction to identify the position of the double bond in an alkene; the alkene is reacted with ozone, 03, followed by hydrolysis in acidic solution. This breaks the molecule where the double bond was, creating two carbonyl compounds which are easily identified. The original structure is pieced together from the two fragments.

PARAFFINIC: Hydrocarbon compounds involving no double or triple C—C bonds; alkanes; saturated aliphatic hydrocarbons.

PARTICULATES: Consisting of minute, separate particles.

PHOTOLYSIS: A chemical reaction produced by exposure to light or ultraviolet radiation. Photolytic reactions often involve free radicals, the first step being hemolytic fission of a chemical bond. The photolysis of water, using energy from sunlight absorbed by chlorophyll, produces gaseous oxygen, electrons, and hydrogen ions and is a key reaction in photosynthesis.

PILOTED IGNITION TEMPERATURE: The minimum temperature at which a fuel will sustain a flame when exposed to a pilot source.

PILOTS: Small gas jets that act to ignite gas to burners.

PLENUM: Hood area behind filters.

PLUME: The column of hot gases, flames, and smoke rising above a fire; also called *convection column, thermal updraft, or thermal column.*

POINT OF ORIGIN: The exact physical location where a heat source and a fuel come in contact with each other and a fire begins.

PRACTICE-DRIVEN RESEARCH: Research done on-site; away from the academy or laboratory, i.e.: "field research".

PREP ISLAND: An island or counter/table-top area used in food preparation.

PRESSURE WASHER: Machines (that most often employ heat as well), used in cleaning metallic (and other) surfaces. Water is pressurized to very high velocities.

PYROLYSIS: The chemical decomposition of a compound into one or more other substances by heat alone; pyrolysis often precedes combustion.

PYROMANIA: Uncontrollable psychological impulse to start fires.

PYROPHORIC: Capable of igniting on exposure to atmospheric oxygen at normal temperatures.

QUALIFIED: A competent and capable person or company that has met the requirements and training for a given field acceptable to the AHJ.

RACEWAY: Any channel for holding wires, cables, or busbars that is designed expressly for, and is used solely for, this purpose.

RADIATION: 1) Simple heat emitted from heating elements. 2) Energy waves from electromagnetic source.

RECEPTACLE: A contact device installed as the outlet for the connection of an appliance by means of a plug.

RANGE TOP: Self-explanatory term for the flat, uppermost surface of a stove which houses the cooking elements or burners. On occasion can refer to grill tops as well.

RECIRCULATING SYSTEMS (NFPA Def.): Systems for control of smoke or grease-laden vapors from commercial cooking equipment that do not exhaust to the outside.

REKINDLE: Re-ignition of a fire due to latent heat, sparks, or embers.

REPLACEMENT AIR UNIT: Mechanical device designed to draw in make-up air.

RESISTANCE: Opposition to the passage of an electrical current.

RESPONSIBILITY: The accountability of a person or other entity for the event or sequence of events that caused the fire or explosion, spread of the fire, bodily injuries, loss of life, or property damage.

RETROFIT: Installation of after-market products and system components; after original manufacture or installation.

RETURN AIR: In HVAC systems; the recycling of indoor air, either for cooling or heating or purifying.

ROOF MEMBRANE: Generally on flat roofs, the sealing cover or layer of tar, tar and poly/paper, or other material.

ROTISSERIE: A rotating device for cooking meat.

SALAMANDER: Upright broiler. An appliance used in preparation of food by exposing food to intense radiant heat and hot-air convection.

SALVAGE: Procedures to reduce incidental losses from smoke, water, and weather following fires, generally removal or covering of contents.

SATURATED: Hydrocarbons that have no double or triple C—C bonds.

SEAT OF EXPLOSION: The area of most intense physical damage caused by high explosive pressures and shock waves in the vicinity of a solid or liquid explosive.

SEAT OF FIRE: Area where main body of fire is located, as determined by outward movement of heat, flames, and smoke.

SELF-HEATING: An exothermic chemical or biological process that can generate enough heat to become an ignition source; spontaneous combustion.

SELF-IGNITION: *See* auto-ignition.

SERVICE: The conductors and equipment for delivering electricity from the supply system to the equipment of the premises served.

SERVICE CONDUCTORS: The supply conductors that extend from the street main or transformer to the equipment of the premises served.

SERVICE DROP: The overhead service conductors from the pole, transformer, or other aerial support to the service entrance equipment on the structure, including any splices.

SERVICE EQUIPMENT: The necessary hardware that constitutes the main control and means of cut-off of the electrical supply, usually consisting of circuit breakers, fuses, and switches located in a panel box near the point of entrance of supply conductors.

SET: Device or contrivance used to ignite an incendiary fire.

SEVERITY: (as used herein) normally refers to the degree of grease accumulation in K.E.Ss.

SHALL: Indicates a mandatory requirement.

SHEET PANS: Large metallic baking/cooking sheets with 1-1.5 cm. lip.

SHORT-CIRCUIT: Direct contact between a current-carrying conductor and another conductor.

SHOULD: Indicates a recommendation or that which is advised but not required.

SMOLDERING COMBUSTION: The direct combustion of a solid fuel with atmospheric oxygen to generate heat in the absence of gaseous flames; *see* glowing combustion.

SOLENOID: A cylindrical coil of wire, which creates a magnetic field within itself when an electric current is passed through it.

SOLID COOKING FUEL (NFPA Def.): Any solid, organic, consumable fuel such as briquettes, mesquite, hardwood, or charcoal.

SOLID FUEL COOKING EQUIPMENT (NFPA Def.): Cooking equipment that is fired with solid cooking fuel. This indicates ovens, tandoori charcoal pots, grills, broilers, rotisseries, barbecue pits, or any other type of cooking equipment that derives all or part of its heat source from the burning of solid cooking fuel.

SOLID FUEL: One form of fuel used in cooking; may consist of charcoal by-products, wood or animal chips.

SOLID WELD: See “Duct”, glossary.

SOLVENT (NFPA Def.): A substance (usually liquid) capable of dissolving or dispersing another substance. A chemical compound designed and used for the purpose of converting solidified grease into a liquid or semi-liquid state to facilitate a cleaning operation.

SOOT: The carbon-based solid residue created by incomplete combustion of carbon-based fuels.

SPALL: Crumbling or fracturing of a concrete or brick surface as a result of exposure to thermal or mechanical stress.

SPARK: Superheated, incandescent particle.

SPARK ARRESTOR: A device or method that minimizes the passage of airborne sparks and embers into a plenum, duct, and flue.

SPOLIATION: The destruction or material alteration of, or failure to save, evidence that could have been used by another in future litigation.

SPONTANEOUS COMBUSTION: Initiation of combustion of a material by internal chemical or biological reaction that has produced heat to ignite the material.

SPONTANEOUS HEATING: Process whereby a material increases in temperature without drawing heat from its surroundings.

SPONTANEOUS IGNITION: Initiation of combustion of a material by an internal chemical or biological reaction that has produced sufficient heat to ignite the material. *See* self-heating.

SQUARE DUCT: See "Duct", glossary.

STEAM COOKER: In commercial terms, refers to a large pressure-styled pot for cooking vegetables, etc.

STOVE TOP: Self-explanatory term for the flat, upper-most surface of a stove which houses the cooking elements or burners. On occasion can refer to grill tops as well.

SUB CEILING: A secondary or "false" ceiling, designed to provide cover for mechanical services such as ductwork, electrical conduit, plumbing, etc.

SUPPRESSION: See "Fire-Extinguishing Systems", glossary

SURFACE TENSION: (physics) the dynamic, molecular attractive properties of certain substances, e.g.: grease adhering to metal surface.

SURFACTANT: A substance that facilitates the spreading of another substance i.e., a detergent.

SUSPICIOUS: Fire cause has not been determined, but there are indications that the fire was deliberately set and all accidental fire causes have been eliminated.

SYNTHETIC: Material that is man-made, usually referring to organic polymers.

SYSTEMS: Assemblies of exhaust ventilation components or fire-extinguishing systems.

TECK SCREWS: Self tapping screws.

TEMPERATURE: The degree of sensible heat of a body as measured by a thermometer or similar instrument.

THERMAL CURRENTS: (physics) when cooking surfaces are heated they generate convection (air) currents of their own. This needs to be factored when calculating CCM/CFM.

THERMAL INERTIA: The properties of a material that characterize its rate of surface temperature rise when exposed to heat, related to the product of the material's thermal conductivity. (k), its density (p), and its heat capacity (c).

THERMAL PROTECTOR: An inherent device against overheating that is responsive to temperature or current and will protect the equipment against overheating due to overload or failure to start.

THERMOPLASTIC: Polymer that can undergo reversible melting without appreciable chemical change.

THERMOSETTING (resin): Polymer that decomposes or degrades as it is heated rather than melts.

TIPABLE: (as used here in) refers to an exhaust fan, which has been designed to be effectively removed from its housing, to aid servicing.

TORCH: A professional fire setter.

TOXIC: Poisonous, capable of causing death or serious injury.

TRAILERS: Longs trails of fast-burning material used to spread a fire throughout a structure.

TRAINED: A person who has become proficient in performing a skill reliably and safely through instruction and practice/field experience acceptable to the AHJ.

TRANSFER AIR: Refers to air that passively moves from one area to another-most commonly used for air that moves from the higher-pressured, dining area of a restaurant to the lower-pressured kitchen (since the Kitchen Exhaust Systems constantly removes air from the kitchen).

TROUGH: (as used herein) part of the hood. A channel or trough which often runs the entire interior, bottom circumference of the hood, into which oil residues can run, after condensing on metallic surfaces.

U.L.(Underwriter's Laboratory): A certified testing laboratory in the U.S. that tests a variety of products to see if they are safe for their intended applications.

U.L.C.(Underwriter's Laboratory Canada): See "U.L.", glossary.

UNLOADER: Safety relief valve on pressure washers to protect against explosions.

UPRIGHT BROILER (NFPA Def.): An appliance used in the preparation of food whereby foods are exposed to intense radiant heat, and perhaps to convective heat, with the food or the food and the radiant source not limited to a horizontal mode.

VAPOR: The gaseous phase of a liquid or solid that can be returned to that phase by the application of pressure.

VAPOR DENSITY: The ratio of the weight of a given volume of gas or vapor to that of an equal volume of air.

VENTED: Fire that has extended outside the structure or compartment by destroying the windows or burning an opening in the roof or walls.

VENTILATION: A technique for opening a burning building to allow the escape of heated gases and smoke to prevent explosive concentrations (smoke explosions or backdrafts) and to allow the advancement of hose lines into the structure.

VENTILATORS: Trade name for Water wash hoods. See Water wash hoods, glossary.

VENTLESS FRYER: These systems require no ducting to the outside of the building.

VOLATILE: A liquid having a low boiling point; one that is readily evaporated into the vapor state.

VOLT: The basic unit of electromotive force.

VOLTAGE, NOMINAL: A value assigned to a circuit or system for the purpose of conveniently designating its voltage class (120/240, 480Y/277, 600, etc.)

WALK BOARDS: Boards cut from different thicknesses-used to cover up and protect cooking components during cleaning.

WASTE WATER: Effluent by-product of kitchen exhaust cleaning.

WATT: Unit of power, or rate of work, equal to one joule per second, or the rate of work represented by a current of one ampere under the potential of one volt; unit of power or work (in electrical circuits, equivalent to voltage multiplied by amperes).

WCB: Workers Compensation Board; a government regulatory body charged with worker safety in Canada.

WHMIS: Workplace Hazardous Materials Information System. An internationally-recognized identification and warning system. (See Introduction)

WOK: A concave cooking pot with a rounded bottom, used in oriental cuisine.

Resources

We would like to thank the following people for their information and contributions to the book.

Access Panels

COMPONENT HARDWARE GROUP, INC.
1890 Swarthmore Ave
Lakewood, NJ 08701
Tel: 732-363-4700 Ext 162
Email: sszprengiel@chgusa.com
Access panel manufacturer

KEES INC
400 Industrial Drive
PO Box L
Elkhart Lake WI 53020
Tel: 920-876-3391
Fax: 920-876-3065
Email: kees@excel.net

MASTER AIR
1720 Wales Ave
Indianapolis, IN 46218
Tel: 317-375-7600

R.L. WILLIAM AND CO INC.
332 West 33rd Street
Edmond, OK 73013
Tel: 405-475-2810

TRUMPF, INC.
111Hyde Rd.
Farmington, CT 06032
Tel: 860-677-9741
Fax: 860-678-1704
Email: info@trumpfusa.com
http://www.trumpfusa.com/
Access Panel cutting tools

Listed Ducts

MASTER AIR, INC
1720 Wales
Indianapolis, IN 46218
wilson@master-air.com

METAL FAB
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Wichita, KS 67201
Tel: 800-835-2830
Fax: 316-943-2717

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656 South Union Avenue
Alliance, Ohio 44601
Tel: 800-872-0338
Fax: 216-823-8686

THERMAL CERAMICS
P.O. Box 923 ms#32
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Tel: 866-785-2763
Fax: 866-785-2764
www.thermalceramics.com

Fans

DELFIELD COMPANY
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Tel: 517-773-7981
Fax: 517-773-3210
Grease Fan Manufacturer

EXHAUSTO, Inc.
P.O. Box 720651
Atlanta, GA 30358 USA
Tel. 770-394-3156 or 800-255-2923
Fax. 770-393-2234
Grease Fan Manufacturer

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Springfield, MO. 65803-4637
Tel: 407-869-6474
Fax: 407-862-0968
http://www.lorencook.com

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Fax: 323-344-4389

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1255 Venables Street
Vancouver, BC. V6A 3X6
Tel: 604-253-6611
Fax: 604-253-0807
Grease Fan Manufacturer

Filters

AIRCON MANUFACTURING COMPANY, INC.
441 Green Street
Philadelphia, PA 19123
Tel: 800-833-3019
Fax: 215-922-5316
Email: filtersales@airconfilter.com
http://www.airconfilter.com

COMPONENT HARDWARE GROUP, INC.
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Lakewood, NJ 08701
Tel: 732-363-4700 Ext 162
Email: sszprengiel@chgusa.com
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Air Filters

Fire-Extinguishing Systems

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Toll Free Fax: 800-248-7809
http://www.badgerfire.com

ANSUL INCORPORATED
1240 Iroquois Drive, Suite 102
Naperville, IL 60563-8537
Tel: 930-305-5700
Fax: 630-305-3360

KIDDE - FENWAL
Kidde-Fenwal, Inc.
400 Main Street
Ashland, MA 01721 USA
http://www.kidde-fenwal.com

Grease Containment Systems

IMPACT ABSORBENTS, INC.
P.O. Box 1131
Atascadero, CA 93423
Toll Free: (800) 339-7672
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Fax: (805) 466-7709
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Hinge Kits

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Gurnee, IL 60031
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Fax: 847-625-6309
Email: daryl@ducts.com
http://www.greasehound.com

Hood and Equipment Manufacturer

AVTEC INDUSTRIES
120 Kendall Point Drive
Oswego, Il 60543 USA
Tel: 630-851-4800
Fax: 630-851-5777

CARROLL MANUFACTURING INTERNATIONAL
23 Vreeland Road
Florham Park, IN 07932
Tel: 973-966-6000
Fax: 973-966-0315
Toll Free: 800-444-9696
Email: jbasha@carrollmi.com
http://www.carrollmi.com

GAYLORD INDUSTRIES, INC
P.O. Box 1149
Tualatin, Oregon 97062-1149 USA
Tel: 503-691-2010
Fax: 503-692-6048
Ventilation and Kitchen Equipment Manufacturer

GILES FOODSERVICE EQUIPMENT
2750 Gunter Park Drive West
P.O. Box 210247
Montgomery, AL 36121 USA
Tel. 800-554-4537 USA and CANADA
Tel. 334-272-1457
Fax. 334-272-3561
Ventilation and Kitchen Equipment Manufacturer

GREENHECK
P.O. Box 410
Schofield, WI. 54476-0410
Tel: 715-359-6171
Fax: 715-355-2399
Email: Alan.B@greenheck.com
http://www.greenheck.com
Ventilation and Kitchen Equipment Manufacturer

HUSSMANN/SECO ENGINEERING
Hussmann Foodservice Co.
Seco Engineering
4550 Gustine Avenue
St. Louis, MO 63116 USA
Tel. 314-481-0669
Ventilation and Kitchen Equipment Manufacturer

QUEST CLEANAIR VENTILATOR CO.
1233 Venables St.
Vancouver, BC V6A 3X7 CANADA
Tel. 604-253-6611
Fax. 604-253-0807
Ventilation and Kitchen Manufacturer

SELKIRK METALBESTOS
Commercial Industrial Product Sales Office
St. Rt. 93 North & Sutton Rd.
P.O. Box 631
Logan, Ohio 43138 USA
Tel. 800-848-2149
Tel. 614-385-5671
Fax. 614-385-2483
Engineered Duct Manufacturer

VENTMASTER KITCHEN VENTILATION
1177 Kamato Road
Mississauga, Ontario, L4W 1X4 Canada
Tel: 905-624-0260
Fax: 905-624-5547
Tel: USA to Canada 1-800-565-2981
Fax: USA to Canada 1-800-665-2438
Email: patmccann@garland-group.com
Ventilation and Kitchen Equipment Manufacturer

Safety Equipment

ARKON INC.
260 Nugget Avenue
Scarborough, Ont. M1S 3A7 CANADA
Tel. 416-293-2172 or 800-268-3517
Fax. 416-292-3330

Spin-Jet

DPW SALES AND SERVICE
901 Ulrich Ave
Louisville, KY 40219
Tel: 502-966 2564
Fax: 502-964-2019
E-mail: info@dpwservices.com

Associations

POWER WASHERS OF NORTH AMERICA
7801 Suffolk Court,
Alexandria, VA 22315-4029
Tel: (800) 393-7962
Fax: (703) 971-7772
Email: pwnahq@aol.com
http://www.pwna.org

COMMERCIAL FOOD EQUIPMENT SERVICE ASSOCIATION
2211 W. Meadowview Road, Suite 20
Greensboro, North Carolina 27407
336.346.4700 (phone)
336.346.4745 (fax)

S.M.A.C.N.A. INC.
P.O. Box 221230
Chantilly, Virginia 22022-1230
Tel: 703-803-2980

UNDERWRITERS LABORATORIES INC.
333 Pfingsten Rd.
Northbrook, IL 60062 USA
Tel: 847-272-8800
Fax: 847-509-6223

Technical Consultants

PHIL ACKLAND & Assoc.
P.O. Box 856
Summerland, BC V0H 1Z0
Tel: 250-494-1361
Fax: 250-494-4216
Email: packland@shaw.ca
http://www.philackland.com

COMPLIANCE SOLUTIONS INTERNATIONAL, INC.
Buffalo Grove, IL 60089-4645
Ph.: 847-383-5088

DEMERS AND ASSOCIATES
42 Highland Street
Lunenburg, MA 01462
Tel: 978-582-4816
Fax: 978-582-7491
E-mail: ddemers917@aol.com

FISHER-NICKEL, INC:
Food Service Technology Center
12949 Alcosta Boulevard, Suite 101
San Ramon, CA 94583
Phone: 925.866.2844
Fax: 925.866.2864
www.fishnick.com

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Lee DeVito
100 Burtt Road
Andover, MA 01810-5920
978-749-2750
978-749-9626
E-mail: fireprobur@aol.com

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Fax: 708-677-3539
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102-11400 Bridgeport Road
Richmond, BC Canada V6X 1T2
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Fax: 1-800-546-3410

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GAYLORD INDUSTRIES, INC.
P.O. Box 1149
Tualatin, Oregon 97062-1149 USA
Tel: 503-691-2010
Fax: 503-692-6048
Ventilation and Kitchen Equipment Manufacturer

VENTMASTER KITCHEN VENTILATION
1177 Kamato Road
Mississauga, Ontario, L4W 1X4 Canada
Tel: 905-624-0260
Fax: 905-624-5547
Tel: USA to Canada 1-800-565-2981
Fax: USA to Canada 1-800-665-2438
Email: patmccann@garland-group.com
Ventilation and Kitchen Equipment Manufacturer

Waste Water Management

ENVIRONMENTAL CLEANING SYSTEM INC.
41 Shaft Road
Rexdale, ON. M9W 4M3
Tel: 416-244-6487
Fax: 416-244-3207
Email: latinat@ica.net
http://www.adpup.com/latimat

KEY ENVIRONMENTAL
287 Lackawanna Drive
Andover, NJ 07821
Tel: 800-821-9741
Waste Water Management

WASTE WATER MANAGEMENT, INC.
150 Venus Street, Suite 303
Jupiter, FL 33458
Tel: 561-747-8028
Fax: 561-747-0642
http://www.RECYKE.com