

FIREPOINT



IAAI JOURNAL



Firepoint

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EDITORIAL

It is a pleasure to again publish the "Fire Cause Analysis" review of Chris Lennard. Chris has been preparing these reviews each three years for the Interpol Forensic Science Symposium. He reviews the literature, contacts major forensic locations around the world, and puts a considerable amount of time and energy into summarising the information received.

Many of our members can benefit from the knowledge, the references, and the contacts noted.

The Australian Federal Police forensic facilities are an important part of our national capabilities.

In the next issue, we expect to have an article on digital photographs, their advantages and disadvantages.

Best wishes to all members for the festive season. Here's hoping next year will be a happier one for you all.

Wal Stern



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The Events of September 11.

Much has already been written about the events in the U.S. on September 11 in New York and Washington, but with the tragic loss of so many innocent fire officers and police, this Association was tragically linked and involved.

Ross Brogan, the Australian Liaison with the IAAI, and himself a fire officer, sent the following message to the IAAI that day:

"As the Australian IAAI Liaison, from myself and from all members of the IAAI in Australia, and, from the members of the New South Wales Fire Brigades Fire Investigation Unit:

To all our colleagues, please accept our heartfelt condolences for the losses, injuries and destruction caused today by the unspeakable acts perpetrated upon your country and your people by the terrorists' acts in New York and Washington.

Needless to say our thoughts are with you and those who have lost loved ones.

The vision we have seen on our television programs are horrific enough without actually being part of the tragedy. If we could offer assistance, we would.

Unfortunately from such a great distance all we can offer is support.

Take care and we wish you luck in your endeavours in finding the culprits and bringing them to justice. Our best wishes to the families of the victims".

Two days later, IAAI President Kranats and Education Foundation President Clark wrote:

"The unfathomable tragedy has left us all asking what we can do. The New York City Fire Department alone has lost as many as 300 brave men and

women in the line of duty in a single event".

The IAAI immediately established a Memorial Fund for the families of victims.

Contributions can be forwarded to this fund at:

IAAI Educational Foundation/Memorial Fund, 12722 Boenker Road, St. Louis, Missouri, 63044, USA.

The fund accepts Visa, MasterCard or American Express, or offers by phone on 314 739 4222 or on e-mail at IAAIHQ@aol.com

The IAAI also initiated steps to develop and present through IAAI Certified Fire Investigators an 8 hour course on "First Responder Terrorist Awareness Program."

The plan is to present this course to any interested Chapter of the IAAI.

VICTORIAN NEWS

NINTH ANNUAL GENERAL MEETING – VICTORIA CHAPTER

On the 24th October the Victorian Chapter held its AGM together with a training session and guest speaker. The meeting was well attended by 39 members at the MFESB Training College at Abbotsford. The main items from the AGM were the election of office bearers and the formal changing of the name of the Chapter.

In the President's report Alex Conway thanked the current committee, the MFESB for their support in the use of the training college and the CFA & SFSC for their support.

Membership of the Chapter is still increasing from 146 members in 1999/2000 to 171 members for 2000/2001. During the year there were eight committee meetings and eight training sessions held, including the seminar in Hobart, Tasmania.

ELECTION RESULTS

Committee for 2001/2002

President	Alex Conway
V/President	Brian Neal
Secretary	Trevor Pillinger
Treasurer	Bob Hetherington
Committee	Nicole Harvey
	Scott Staunton
	(Legal Officer)
	John Kelleher
	Tony Mandarano
	George Cooney
	Noel Desair
	Peter Endler

The formal change of the association in name to:

**VICTORIAN ASSOCIATION OF FIRE INVESTIGATORS (VAFI)
(including Tasmania) INC.**

was passed and ratified by those members in attendance.

Our Guest Speaker was Ross Brogan, the IAAI Liaison Officer, and he spoke about the International Seminar and the videos, books and CD that have been made available to the Chapter.

He encouraged Chapter members to join the international IAAI and reported the new system of postal voting for all members and the move to have the fees reduced to \$50.00 internationally not US as at present. He also recommended that all members should consider going to the international seminar which is in Milwaukee, Wisconsin, May 2002. Ross also mentioned that NSW Chapter has a Website.

In his final remarks he reported on the IAAI Memorial Fund to support fallen Public Safety and Law Enforcement members and their families following the recent tragic events in America. With this in mind the Victorian Chapter has donated a total of \$460.00 collected on the night for this Fund and this will be forwarded.

Following the completion of the AGM, a discussion session dealing with a similar incident of a large magnitude that happened in America. What if it

happened in Melbourne? Discussion points that were covered included initial management of the scene, responsibilities of individual agencies, (Fire, Police, Rescue) State, intrastate and interstate support, scene support, DVI, investigators role and insurance role. The discussion showed that procedures are in place in Victoria and that the roles of agencies are defined, but the magnitude of the task may cause some problems. Our thanks to our panel members:

Greg Usnouf	CFA
Frank Stockton	MFESB
John Kelleher	SFSC
Paul Millet	POL(ARSON SQUAD)
Peter Doyle	USAR
Terry McCabe	Insurance Rep.
Bob Hetherington	MFESB -CIS

TRAINING SESSION

The following is a list of Training sessions that have been identified for next year. Each session will be advertised to all members via a flyer and it is important that you reply so that numbers can be forecast prior to the event. As you can see we are intending to hold a two day Seminar in September 2002 and any requests or ideas from the membership should be directed to the committee. Thank you to the members who have supported the training sessions throughout the year.

DECEMBER 2001
ELECTRICAL

MARCH 2002
EXPLOSIVES

MAY 2002
PHOTOGRAPHY & EVIDENCE

JULY 2002
AGM & TRAINING SESSION TBA

SEPTEMBER 2002
SEMINAR TWO DAYS

OCTOBER 2002
TRAINING SESSION TBA

DECEMBER 2002
TRAINING SESSION TBA

MEMBERSHIP

Although the membership of the Chapter is around 171, it is important that you are a financial member. In December a review of the membership list will be undertaken and unfinancial members will be notified. All members should be on the lookout for any new members.

EMAIL ADDRESSES

Due to the cost of mailing information, the committee has now a database of about 80% of the membership on Email. Members should have received the December Training Flyer via this medium. It is important that to keep up good communications and that if you change your e-mail address please notify the registrar Bob Hetherington.

COMMITTEE MESSAGE

Being the last Firepoint prior to the Christmas break and the Festive Season, the committee wishes all Chapter members and families and those Australia wide, a merry Christmas and a safe and enjoyable break over the season and a prosperous New Year.

NEW SOUTH WALES NEWS

A Message from the President

Your Committee recently sacrificed a lovely sunny Sunday to meet at the Ryde Eastwood Leagues Club, not to play the pokies and drink grog, but to develop a business plan for the future direction of the Association.

It was a very positive and progressive meeting in which a 12 month, 2 year and 5 year plan was mapped out. Sub-committees have been formed to focus on various area of activities, and by the end of the day we all had a much clearer picture of where we are heading.

I would like to thank all the members who attended for their valuable input, and for giving up a large part of their weekend. I'm sure the value of the day will be realised in the future.

All attendees of this year's Annual Conference should soon receive their interactive virtual reality fire investigation CD. It was intended that they be presented to attendees at the Conference, but the Canadian mail system had a shortage

of sleighs and huskies that month, so it took a little longer for them to arrive here. The CD has a scenario section where you examine physical evidence, interview witnesses, etc.

It also has a tutorial section with a suggested model protocol for investigation of fires.

I'm sure it will be a quality training tool for members.

Christmas is almost upon us and I would like to wish all members and your Committee a very Happy Christmas with lots of excess in

everything that makes you feel good.

Don Walshe
NSW AFI President

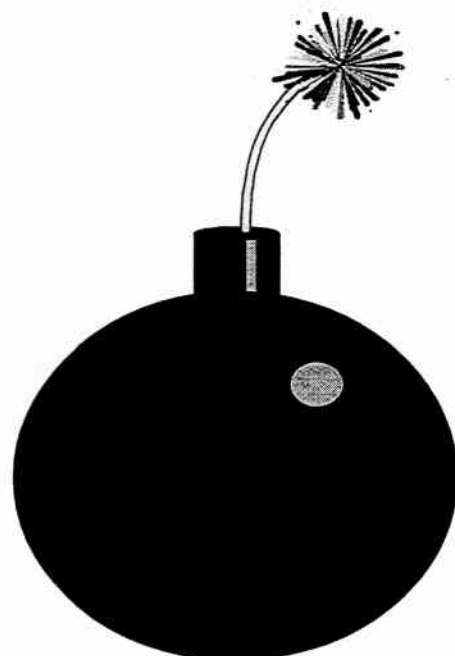
IAAI AGM 2002

The 53rd IAAI AGM will be held May 19-24, 2002 at the Sheraton Four Point Hotel, Milwaukee, Wisconsin, USA.

Registration costs are \$US 300-450.

Room rates are \$US 95

If you would like to receive a Registration Form or information leaflets or have any questions concerning the Conference check out the website at www.wiaai.com



QUEENSLAND NEWS

WELCOME

Welcome to the final edition of Firepoint for 2001.

On reflection it has been a year touched by tragedy and one that we will never forget. On September 11 we awoke to the tragic news of the first terrorist attack on the Twin Towers in Manhattan, New York. The chain of events that followed the initial attack and our ability to view these events live via television coverage was horrific enough without actually being there.

Unfortunately from such a great distance, all we here in Australia could offer was our heartfelt condolences and support.

The Officers and Directors of the International Association of Arson Investigators established a Memorial Fund for the fallen public safety and law enforcement heroes and their families. The IAAI Education Foundation will collect all donations and forward them directly to the appropriate agencies on our behalf.

In support of this endeavor, on behalf of the QAFI members, the Chapter donated US\$301 to the fund, which represents the 300 fallen Firefighters plus one dollar for the "Missing Person".

During the upcoming festive season, let us all spare a thought for those that have been touched by tragedy during 2001.

On behalf of the QAFI Committee, I wish to take this opportunity to thank you for your ongoing support of the QAFI and to wish members Australia wide a very merry Christmas and a safe, happy and prosperous New Year.

NEW MEMBERS

The Queensland Chapter welcomes the following new member.

- **David Prain** – Fire Scene Examiner – Qld Fire & Rescue Authority – Mossmon.

QAFI MAJOR PROJECT TRAINING SEMINAR

"PREVENTION IS BETTER THAN CURE"
Friday 8 & Saturday 9 March, 2002

Day 1 Conference & Formal Dinner
Royal On The Park, Brisbane City

Day 2 Live Fire Demonstrations
QFRA Training Facility, Whyte Island

Overview

The project will focus on the theme that prevention is better than cure – the emerging relevance of risk assessment processes in regard to the issue of loss caused by fire.

On 8 March 2001 a series of seminars will be held at the Park Royal Hotel, Brisbane. Topics will include:

- The relevance of the Building Certification Process to risk assessment of commercial premises;
- Conflicting duties and obligations for owners and tenants of commercial premises in complying with insurance requirements;
- The effect of constant change in legal and legislative requirements on the construction and operation of commercial premises;
- The benefits of risk assessment to policy holders and insurers;
- Identifying common ignition sources and other related risks;
- The increasing benefits of Fire Retardant materials.
- The use of computer modeling in both pre and post fire scenarios;
- How can fire risks be minimised once they have been identified.

Various Australian and International experts have been invited to present papers on these topics. Further details will be provided once the availability of all speakers has been confirmed.

On the evening of 8 March 2001 a delegate dinner will be held at the Royal On The Park, Brisbane. The QAFI has invited a well-known international expert to present a key note speech at the dinner. More details upon confirmation of the speaker's availability.

On 9 March 2001, a live fire exercise will be conducted at the new Whyte Island training facility to test the theories raised by the various presenters. A simulated fire at commercial premises is being organised and will include:

- testing the accuracy of computer modeling in anticipating how a fire will behave in certain circumstances;
- the effect of common ignition sources; and

QUEENSLAND NEWS

- the use of fire retardant materials in a building's construction.

Delegates will also view a petro-chemical burn during the split sessions on Day 2.

The project will be useful to members of the insurance and building industries as well as owners of commercial premises and those involved in the examination/investigation of commercial fires.

This project will be educational and a useful information sharing opportunity for those who attend. It is also hoped that it will also 'spark' discussion and debate within the Australian insurance, building and emergency service communities about new ways to respond to the problems caused by fire.

Further information and registration details will be circulated shortly so stay tuned.

SPONSOR THANK YOU

As the end of another year is fast approaching, I wish to formally thank our 2001 Chapter sponsors being;

Major Sponsor

- **Deacons (Lawyers)**

Supporter Sponsors

- **Freemans Australia**
- **Kennedy's (Forensic)**
- **Munters Restoration Services**

The ongoing support the QAFI receives from our annual sponsorship program enables the Chapter to achieve its goals.

Once again, **THANK YOU.**

2002 MEMBERSHIP RENEWAL

Invoices for the 2002 membership renewal will be forwarded in mid December for payment by 31st January 2002.

Remember that all members should be on the look out for any prospective new members.

PRODUCT RECALLS

In the interest of public safety, the Electrical Safety Office would like to bring attention to these product recalls.

Please note this is not a complete list of all recalls involving electrical appliances in Australia, but these recalls are highlighted due to particular safety issues.

The recall notices were released voluntarily by the responsible company through the Commonwealth Department of Treasury, Consumers Affairs Division and published in major Australian Newspapers.

The Commonwealth Department of Treasury has established a national recall website that lists all current product recalls including electrical products. For further information visit www.recalls.gov.au.

RECENT RECALLS



Safety 1st Auto Sensor Night Light -Return to place of purchase for full refund.



Powerhouse Inverters DC-AC -- Models M8042; M8142; M8146; and M8153. Return to place of purchase for full refund.



Aquariums - "AlfaPet Complete 5 Gallon Octagon" & "TOM New Aquatic Décor Natures Window". Return to place of purchase for full refund.



Macintosh PowerBook G3 notebook 45W AC adapter - Model M4402. Supplied May 98 to Mar 2000. Call Apple Australia on 1800 001 912 bet. 8am to 6pm for free AC adapter replacement.



Butterfly Night light -- Labelled "Sound Tech HL-B01". Return to place of purchase for full refund.



Nokia Modem -- Models M1122 and MW1122DSL. Do not disconnect cord from notebook. Phone (02) 9513 9501 to arrange an electrical safety inspection.

"Success seems to be largely a matter of hanging on after others have let go".

- William Feather

Fire Cause Analysis

A Review: 1998 to 2001

By Dr Chris Lennard

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This paper is part of a presentation by Dr Lennard for the 13th Interpol Forensic Science Symposium held in Lyon, France, in October, 2001. A second part of this paper describes details of changes in laboratory analyses of fire debris samples. If you would like a copy of this second section contact the Firepoint Editor by email on Wal.Stern@uts.edu.au. A copy of the paper will then be forwarded by email to you.

INTRODUCTION

This review paper covers advances in scientific methods applied to fire cause analysis reported since the 12th INTERPOL Forensic Science Symposium in October 1998. Major forensic laboratories from around the world were asked to provide information on both published articles and internal research reports in this area. A literature review was also conducted, covering articles published in the principal forensic science journals over the period in question (up to May 2001). This was supplemented by an extensive search of "Chemical Abstracts" (American Chemical Society), "SciFinder Scholar" (American Chemical Society), and the Internet, for articles related to fire investigation in the forensic arena. The final report is a collation of information received from these various sources.

SCENE EXAMINATION & GENERAL FIRE INVESTIGATION

General

The National Institute of Justice (1) and the National Fire Protection Association (2) have published standard guidelines for fire scene examination and arson investigation. Book chapters on all aspects of fire investigation have also appeared (3–10). The proceedings from an international symposium on the forensic aspects of fire investigation, sponsored by the Federal Bureau of Investigation, have been published (11).

Karisson and Quintiere (12) have published a book designed to provide the reader with an academic understanding of the dominating mechanisms influencing fire development in enclosed spaces. Their book, *Enclosure Fire Dynamics*, is a valuable resource for individuals involved in fire scene investigation and reconstruction. Lilley (13) has published a review on fire dynamics, including fundamental principles on ignition, fire behaviour, and fire development.

Technical working groups have been established in Europe and North America to coordinate research efforts and develop

protocols for fire and explosion investigation, including the laboratory analysis of debris. The Technical Working Group for Fire and Explosions (TWGFEX) was established in the USA during a symposium in 1997 that was attended by professionals from analytical and crime scene disciplines (14). TWGFEX, sponsored by the National Center for Forensic Sciences (NCFS), has been involved in the development of national guidelines for the collection and analysis of fire and explosion debris, as well training and research to improve the quality of fire and explosion investigations. The Fire and Explosion Investigation Working Group (FEIWG) of the European Network of Forensic Science Institutes (ENFSI) was established in 1998 and currently has members from 22 European countries (15, 16). The working group has been examining European-wide fire investigation methods and is currently establishing guidelines for fire scene and fire debris analysis, quality assurance, and training. Other issues being addressed by FEIWG includes fire debris packaging materials, accelerant databases, and computer modelling. Funding has also been obtained from the European Union to carry out a series of live test burns that will go ahead later in 2001.

In the 1993 case *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, the US Supreme Court set new restrictive rules for evaluating the admissibility of scientific and expert testimony based on relevance and reliability. The *Daubert* opinion instructed trial judges to act as 'gatekeepers' in deciding which types of scientific evidence to allow juries to hear. The trial courts were to hold preliminary hearings under *Federal Rule of Evidence*

702 at which the scientists would explain their methods and conclusions. The judge would then decide, using a series of criteria for scientific validity, whether the testimony was accurate enough for the jury to hear. The Supreme Court identified five factors to examine in relation to *Daubert* challenges: (a) whether the theory has been tested before; (b) whether the theory has been subject to peer review; (c) whether there is a known rate of error; (d) whether standards or controls exist; and, (e) whether the theory is generally accepted by the relevant scientific community. According to some courts, *Daubert* has forced a re-examination of types of evidence that had always been permitted under the old rules. The potential exclusion of previously accepted evidence may be one of *Daubert's* most important effects. Brannigan (17) has considered the impact of *Daubert* on arson evidence, and the possibility that such evidence may end up being excluded as unscientific. In a second article, Brannigan and Torero (18) highlighted some of the special legal and technical problems with key provisions of the National Fire Protection Association's 'Guide for Fire and Explosion Investigations' [NFPA 921] (2). The authors conclude that, for the admissibility of arson expertise, three critical steps are required: (a) the separation of data collection from inferences; (b) demonstration of the repeatability of the analytical methodology; and, (c) the use of full-scale burns and fire models to reconstruct fires.

A number of recent court rulings on the application and interpretation of *Federal Rule of Evidence* 702 on the admissibility of scientific evidence have re-emphasised the need for expert testimony to be reliable.

Stauss and Hogan (19) provided an example where the testimony of three experts in a fire case was rejected by the Court of Appeals based on a perceived lack of reliability. The authors concluded that experts need to self-limit their opinions to their areas of expertise and the actual material facts of the particular case. If the bases for an opinion cannot be supported by other evidence (such reliable eyewitness verification, physical evidence, laboratory analysis, scientific testing, etc.), then the opinion is based on speculation and should be rejected by the court.

Lentini (20) reported on an arson investigation and subsequent trial that lead to the conviction of the defendant (*Commonwealth of Pennsylvania v. Han Tak Lee*). The methodology used by the investigators was examined, as was the presentation of expert testimony in the trial. The paper illustrates the need for trained scientists to become more involved in the collection and documentation of evidence, and to testify in a manner that does not magnify the certainty or importance of otherwise inconclusive data.

Combustion Studies

DeHaan and coworkers (21) described experiments in which the combustion of animal tissue (pork) was measured under a variety of conditions that may be encountered in fire scenes. It was demonstrated that animal tissue could be burned in a hot but localised fire fuelled by rendered fat absorbed into a charred porous substrate (acting like the wick in a kerosene lamp). Extensive thermodynamic data are reported from these tests, together

with implications for the consumption of human bodies in fires.

In a limited number of fire death cases, the body of the victim is found with intensive fire destruction of the torso, while damage to surrounding furnishings and building is minimal. Such cases may be incorrectly described as 'spontaneous human combustion' as it is thought that a 'normal' accidental fire intense enough to consume a body would necessarily be large enough to incorporate an entire room. DeHaan and Nurbakhsh (22, 23) reported a combustion study using the same experimental protocol as before but using a larger (~100 kg) animal carcass that would more closely resemble an adult human body. Measurements were also conducted using a cone calorimeter to validate the equivalency of using pig carcasses rather than human cadavers for such tests. The data obtained from this study serve as a useful base for establishing the fire conditions produced when a body is involved in a prolonged fire of limited size.

Bohnert and coworkers (24) observed and documented the changes that occurred during the cremation of 15 undissected human bodies. It was found that the complete incineration of a human body took about 2–3 hours. The study serves to relate the destruction of a cadaver to the duration of a fire.

DeHaan (25) described a total of ten fires set by various means in furnished compartments and discussed the observed fire spread and the temperature data collected. The fires were all allowed to go to flashover and maximum temperatures in the range of 980–1040° C were measured. Such high temperatures were observed at both floor and ceiling levels regardless of

whether or not flammable liquid accelerants were employed. The author hopes that the results of these tests will be kept in mind when forensic investigators are evaluating the post-fire indicators of fire behaviour. Unscientific theories about flammable liquid fires *always* being hotter than ordinary combustible fires, and floor level burning *always* being the result of flammable liquids still hold sway with some investigators.

It has been demonstrated by DeHaan and coworkers (26, 27) that vapours from flammable liquids (hexane) establish highly stratified, low-lying layers when evaporating from pools into still air, and that deflagrations of such layers produce uniform pressures throughout the compartment. Lapina and Sokalski (28) have developed a model to estimate the time period required for a propane leak to produce a volume fractional concentration equal to the lower explosion limit (LEL) of propane in air.

Paul (29) has published a review on ignition and flammability tests for plastics, rubbers and textile materials. Applicable test standards and their application are also considered for parameters such as flame spread, heat release rate (HRR), and smoke generation, as well as corrosivity and toxicity of fire gases.

Electrical Fires

A significant proportion of structure fires is attributed to ignition from electrical faults associated with wiring or with wiring devices. Despite this, the modes in which electrical faults progress to the ignition of structures have not been extensively studied. Babrauskas (30) has reviewed

published information on the subject and points to areas where additional research is required. The author concludes that systematic research has been inordinately scarce, and that much of the published research that does exist is only available in Japanese.

The forensic investigation of a fire will often involve the post-fire examination of electrical panelboards and circuit breakers if such equipment survives the fire. Sometime a tripped (or untripped) circuit breaker is used to prove or disprove theories about the cause of the fire. However, the heat from a fire may be transferred to a circuit breaker and cause it to trip in the absence of an overcurrent condition. DeWitt and Adams (31) have reviewed the operating principles of thermal-magnetic circuit breakers, described a series of heat transfer tests conducted on a range of circuit breakers, and discussed the potential impact of heat transfer on circuit breaker performance during fires.

Goodson (32) has described the principles of operation of Ground Fault Interrupters (GFIs) designed to prevent deaths caused by exposure to electrical current. If a portion of the electrical current has been diverted to ground, as is the case with an electrocution, the GFI trips, cutting off the power to the circuit. The author explains how GFIs may prevent some electrical fires (such as those brought about by physical damage to energised cables) and indicates their relevance to the way in which electrical fires are investigated. VanderPas and Lewis (33) reported several fires originating from GFI receptacles located near wash basins. The fires were attributed to the corrosion of components in the GFIs.

Surge suppressors are devices used in electrical equipment to protect the equipment from voltage transients (spikes) that could otherwise cause damage. Most surge suppressors make use of Metal Oxide Varistors (MOVs) that are intended to minimise the effect of short-lived power disturbances. Goodson (34) has highlighted the fact that MOV's can fail under certain conditions and that this failure may initiate a fire.

Fires often result from arcing faults within electrical cords, cables and other electrical devices. Hagimoto and coworkers (35) have summarised the characteristics of such arcing and reported on experiments conducted on electrical cords and cables insulated with polyvinyl chloride (PVC). The tracking resistance of insulating materials degraded by heating in an electrical furnace has been investigated by Okamoto and coworkers (36). Ashizawa (37) has studied the processes involved in the progression from thermal degradation to ignition of an attachment plug due to the joule heating of a defective contact between socket receptacles and plug blades. Crawford (38) has presented cases where fire has resulted from the slow deterioration of overheated electrical insulation. The cases demonstrate that carbon-based insulation can become conductive when stressed by long exposure to moderate heat.

Electrical Molten Marks (EMMs), resulting from arcing between electrical wiring, are present at nearly all structural fire scenes. A reliable technique for differentiating between primary molten marks, indicating arcing as the cause of the fire, and secondary molten marks, indicating arcing as a result of the fire,

would be of particular value to the fire investigator. Lee and coworkers (39, 40) studied the crystal structure of the carbon in carbonised residue caught in artificially-prepared primary and secondary EMMs. They found that both graphite and amorphous carbon was present in the primary EMMs, while the secondary EMMs only exhibited amorphous carbon. This suggests that the presence of graphite may serve as an indicator of primary EMMs (and hence arcing that has caused the fire). In a further study, it was found that the surrounding temperature at the formation of an EMM could be estimated by measuring DAS (Dendrite Arm Spacing) and oxide concentration (41).

Goodson and coworkers (42) have reviewed a number of cases that demonstrate how electrical energy in a fault situation can travel along a gas line, creating a gas leak and a resultant fire. Of importance to the investigator in such situations is an appreciation of how gas fittings may be damaged by an electrical current. The operation of electric water heaters has also been reviewed, with a conclusion that the heaters themselves do not generally cause fires (43). Fires involving electric water heaters are most probably caused by an overheated connection, or a direct short that occurs in close proximity to combustibles. Conditions under which a fire is possible from a halogen lamp have been discussed (44). The main danger is from combustible material falling on the lamp shade, in close proximity to the halogen bulb. However, the long-term failure of a halogen lamp can sometimes result in an 'exploding light tube' that ignites any readily combustible material near the lamp (45).

Non-Electrical Fires

Lighted cigarettes can ignite materials that are capable of smouldering, whereas commonly encountered solid materials are not ignited directly by such a source. Holleyhead (46) has discussed the mechanism of ignition of solid materials by cigarettes, the smouldering process, and the transition of a smoulder to flaming combustion. In addition, the results of tests to ignite solid materials and the components used in the manufacture of furniture, especially polyurethane foam, have been reviewed.

Bishop and DeMars (47) considered how easy it was to ignite a Christmas tree using an 'accidental' source such as shorted wires, matches, or butane lighters. Experimental results indicated that it was very difficult to get a Christmas tree to sustain a flame when ignition was by some ordinary means. The authors concluded that it was unlikely that an ordinary Christmas tree will ignite and cause a fire where the tree itself is the initial fuel.

Hagimoto and coworkers (48) reported that a significant number of fires in Japan are caused by welding and cutting sparks at construction sites. The authors investigated the generation and dispersion of particles that resulted from the use of electrical welding equipment. They found that welding particles could readily ignite many combustible materials, including combustible liquids of high flash point. The investigation of fires involving gas-fired water heaters and fuel oil furnaces has been discussed (49, 50).

Ezekoye and Martin (51) reported on a violent explosion that resulted from a metal paint thinner can being refilled with kerosene at a refuelling station. Significant static charges can build up in a petroleum-based fuel flowing through a tube. If the fuel container being filled is metal and is not grounded (as was the situation for the case in question), the charges that

accumulate at the tip of the fuel nozzle can result in a spark between the nozzle and the container. Such a spark may contain sufficient energy to ignite flammable vapour in the container.

Nic Daéid and Thain (52) have indicated that many domestic fires in Scotland result from the incorrect or careless use of candles of various types. Candles known as 'night lights' or 'tea lights', very popular with consumers, are small and encased in an aluminium dish. The authors report on the temperature increase of the metal container over time, under various airflow conditions. Under certain circumstances, temperatures were reached that could result in ignition of some surfaces.

Roby and Carpenter (53) have discussed the role of carpet in determining the origin and cause of a compartment fire. The authors consider how carpet behaves with respect to compartment fires and include examples of how such information can be used to help support findings from other sources.

Vehicle Fires

Investigators are frequently presented with the problem of investigating total loss, or 'black hole', motor vehicle fires. This type of fire is characterised by the total consumption of every combustible item in the vehicle. Such vehicles are often reported stolen, with the motive for the fire being insurance fraud. Wendt (54) has considered the difficulties associated with such investigations and has emphasised the need for a 'global perspective' to conduct a thorough and complete inquiry.

Gomez (55) has conducted studies to determine if it is possible to enflame a vehicle using a portable ignition source such as matches or butane lighters. The direct ignition of a vehicle tire was unsuccessful. However, it was found that certain polymer fittings on the exterior of a

vehicle could be ignited and that this could lead to a fire that readily penetrated to the interior of the vehicle.

Spontaneous Combustion

There has been debate over whether or not wood that has been exposed to long-term, low-temperature heat sources (below about 150° C) can generate char that may result in spontaneous combustion. Babrauskas (56) has questioned claims that the concepts of 'pyrophoric carbon' or 'pyrophoric char' have been disproved through scientific research. The author argues that such claims are premature and further research is required on the subject.

Sanderson and Schudel (57) have considered the possibility that the spontaneous combustion of lint may be the most common cause of residential clothes dryer fires. Oils used in cooking are somewhat subject to spontaneous heating and may cause fires associated with dryers under certain circumstances. However, the authors report that none of the results from 16 tests they conducted showed any evidence of spontaneous heating in lint samples.

Several laundry fires have been reported in the United Kingdom and Ireland where the cause is thought to be spontaneous combustion, specifically of fatty acids (such as linoleic acid) that may be present on cotton materials after the laundering process. Combustion has been known to occur amongst freshly laundered and tumble-dried clothing if the materials are heaped or stacked immediately after drying. Nic Daéid and Walker (58) found that significant levels of linoleic and oleic acids (known constituents of human sweat) were recoverable from cloth even after very hot washing cycles (90° C). It was concluded that, if such materials were then exposed to heating (during the tumble-drying process) such that auto-oxidation

temperatures were reached, then spontaneous combustion was conceivable if the subsequent heat was not allowed to dissipate.

Cooper and coworkers (59) investigated the phenomenon of spontaneous combustion of common fibrous evaporative cooling filters originating from paint booth filtration systems. A modified oven test method was utilised to predict the likelihood of spontaneous ignition over a range of ambient temperatures, with specific focus on lower temperatures. The background for the study was a multimillion-dollar structural fire where the exact fire cause was undetermined, but the spontaneous combustion of paint filters could not be eliminated as a possibility.

Accelerant Detection Canines

Accelerant detection canines (ADCs) have assisted fire investigators at fire scenes since the early 1980s. The use of ADCs, trained to specifically locate trace amounts of ignitable liquids, has proliferated at a significant rate. Roberts and Roberts (60) have argued that the olfactory capability of canines should not be used in fire investigations for three reasons: (a) there are significant hazards for the dog at a fire scene (toxic fumes, sharp objects, unstable surfaces, etc.); (b) there is a common problem of assigning dogs capabilities that they do not possess (for example, dogs cannot determine intent and have no sense for the issue of cross-contamination); and, (c) the use, even presence, of an 'arson dog' at a fire scene can be an influence, direct or subconscious, that destroys objectivity.

Lynch and Sawyer (61) discussed a California arson trial where results from the analysis of fire debris samples were

challenged based on an allegation that cross-contamination may have occurred at the scene by the actions of an ADC. The authors recommend that ADC organisations test such propositions through a series of controlled experiments. Unless it is scientifically proven that cross-contamination by ADCs does not occur, such allegations are likely to persist.

Sample Collection & Packaging

Containers for the collection and storage of fire debris samples should be durable, inert, impermeable to volatile materials, and devoid of any residues that may interfere with test results. Unused lined or unlined paint cans, glass jars, and special-purpose polymer bags have traditionally been used for this purpose. Mann (62) has published results from a study designed to test and compare these containers. Issues addressed included background volatiles, permeation of the container seals by hydrocarbon-based volatiles, irreversible adsorption of hydrocarbon-based volatiles by the container membrane, effects of temperature on storage, and sample cross-contamination. The data indicated that the cleanest and most leak-free container for storage and analysis of fire debris samples is a well-sealed specialty polymer bag. Care must be exercised, however, with the packaging of debris with sharp edges. A metal can with a friction-fit lid provided the least protection from sample loss and cross-contamination. Accelerant leakage from metal paint cans was confirmed in experiments reported by Birchall (63).

Delémont and Wistedt (64) have surveyed the packaging devices (metal cans, glass jars, plastic bags) used by ENFSI forensic

laboratories for the sampling of fire debris. Extensive studies are currently under way to evaluate the permeability of different polymer bags to gasoline vapours. Cryovac and Globus brand polyethylene/polyvinylidene dichloride bags have been tested by Kocisko (65) for their suitability in storing ignitable liquid evidence. The bags were found to absorb components of diesel, kerosene, and gasoline, and were also found to produce interfering by-products that complicated the interpretation of chromatographic profiles. The unsuitability of these bags as a means of packaging fire debris highlights the need to test evidence containers to ensure that analytical results are not compromised.

A survey was reported by Lang (66) where stocks of glass mason jars used for fire debris collection were analysed by headspace gas chromatography for possible background contaminants. The majority of mason jars exhibited no appreciable contamination that would interfere with typical fire debris analyses. Approximately one-third of the jars showed trace level contaminant peaks in the range of C8 to C18. Such contaminants would not be incorrectly identified as an ignitable liquid and would potentially interfere with the analysis of only trace level accelerants. Procedures were subsequently developed to prevent container contamination and ensure consistency in container handling.

The possibility of cross-contamination between packaged liquid gasoline and other samples, in simulation of a casework submission, was evaluated by MacManus (67). Glass mason jars and glass vials, combined with nylon bags, were tested as containers for liquid gasoline by packaging

them together with empty mason jars for one month. The indications of gasoline detected in several of the empty glass jars by headspace gas chromatography were not considered sufficient to definitively show that cross-contamination would occur under such circumstances. However, care must still be taken when packaging suspected volatile ignitable liquids with fire debris samples for laboratory analysis.

Doyle (68) has evaluated the use of a 3M brand high capacity hydrophobic sorbent as a sampling medium for liquid accelerant residues at fire scenes. The product is designed for commercial applications such as adsorbing organics (oil and petrol) from factory floors. It was found that the 3M sorbent is extremely sensitive to gasoline vapour and will still render an identifiable chromatogram when there is as little as 5 ppm of gasoline in air.

Training & Research

Berrett and Candy (69) have summarised the current situation with respect to the training of fire investigators in the United Kingdom. While there has been a significant lack of such training in the past, a number of new initiatives have given rise to optimism. Courses with a strong practical element have proven to be the most successful.

An interactive, CD-ROM-based training package for fire investigators has been developed in the USA by a public-private partnership comprising the Bureau of Alcohol, Tobacco and Firearms (ATF), the US Fire Administration (USFA), private industry (American Re-Insurance Company), and a host of professional organisations [including the National Fire

Protection Association (NFPA) and the International Association of Arson Investigators (IAAI)] (70-73). The training program, known as 'interFIRE VR', uses the latest in photo-realistic virtual-reality technology to present lessons on best practice in fire investigation. The software has three working sections that include a series of video-clip-based tutorials, a reference file, and a casework scenario that allows the user to 'respond to a call' and conduct an investigation from start to finish.

With the increasing complexity of fire investigations and the courts demanding that only 'valid scientific methods' be used to evaluate fire scenes, technical assistance for investigators is becoming more important. Tontarski (74) has presented the concept and operation of the ATF's Fire Research Laboratory (FRL) and Fire Research Center (FRC). The FRL, a partnership between law enforcement, fire services, public safety agencies, industry and academia, is designed to promote and support the greater use of fire science in fire origin and cause determinations. The facility provides a controlled environment where fire investigation theories can be investigated and fire propagation scenarios reconstructed on a large scale.

The future of fire investigation has been considered by Madrzykowski (73). The use of digital imaging, virtual fire scene reconstruction, mathematical fire simulations, and remote computer modelling, is expected to increase significantly over the next decade. Such technology is being actively researched within the National Institute of Standards and Technology (NIST) Building and Fire Research Laboratory. The author provides

an overview of where the state-of-the-art research is at and where it is heading.

Internet Resources

The Internet explosion has continued over the last three years, with most agencies and organisations involved in fire investigation now hosting web sites to support investigators (75-84). Information contained on these sites, including links to other sites of potential interest, provides a wealth of material to assist the fire investigator. Easy access to such information is complimented by the increasing use of electronic mail (e-mail) as the communication tool of choice for contacting interstate and international colleagues. It is expected that, as network capabilities and computer technologies improve, more advanced applications to assist the fire investigator will become available.

CONCLUSIONS

A review of the relevant forensic literature published over the last three years (1998 to May 2001), covering areas related to fire cause and fire debris analysis, has highlighted the following:

- Several agencies have published standard guidelines for fire scene examination and arson investigation. In addition, technical working groups have been established in Europe and North American to coordinate research efforts and develop protocols for fire and explosion investigation, including the laboratory analysis of debris.
- Several court rulings in the USA have lead to new requirements for evaluating the admissibility of scientific and expert testimony based on relevance and reliability. The implications of these rulings on the admissibility of fire and arson expertise have been considered by a number of authors.
- Several combustion studies, some conducted on animal carcasses, have lead to a better understanding of how human bodies are consumed in fires.
- The study of electrical causes continues to be an area of research activity, with several reports being published that may provide assistance to fire examiners. However, further research is still required to gain a better understanding of the modes in which electrical faults progress to the ignition of structures.
- Research reports have been presented on fire cause by non-electrical means including lighted cigarettes, welding sparks, and candles. The possibility of spontaneous combustion has been considered in cases involving charred wood, clothes dryer lint, and tumble-dried clothing.
- The use of accelerant detection canines to provide assistance to scene examiners when selecting fire debris samples for accelerant analysis has been questioned by a number of authors. Issues including hazards to the

dog and possible scene contamination have been raised.

- Containers for the collection and storage of fire debris have been evaluated in a number of studies.

A range of different packaging materials (including unused paint tins, glass jars, and polymer bags) continue to be used.

- CD-ROM-based virtual reality software has been developed as a training and reference resource for fire scene examiners. This form of training package is likely to become more common in the future, across all forensic science disciplines.
- The use of digital imaging, virtual fire scene reconstruction, mathematical fire simulations, and remote computer modelling, is expected to increase significantly over the next decade.
- The Internet explosion has continued over the last three years, with most agencies and organisations involved in fire investigation now hosting web sites to support investigators. Information contained on these sites, including links to other sites of potential interest, provides a wealth of material to assist the fire investigator. It is expected that, as network capabilities and computer technologies improve, more advanced forensic applications will become available.

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