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A critical review of canines used to detect accelerants within an arson crime scene

Abstract

Accelerant detection canines provide a fundamental role in arson investigations. Statistically, arson and criminal damage accounts for 9 per 1,000 population in the UK.[1] Before 1996, fire investigators relied on the olfactory system and basic accelerant detection equipment to locate accelerant traces within arson crime scenes. As a result, canines were adopted as their superior olfactory system was producing precise detections than those of technical equipment. This review proposes that despite their strong sense of smell, the accuracy of detections remains fundamentally unanswered. Although current literature demonstrates extraordinary results from accelerant detection canines, further developments and critical evaluations are required to ensure the process meets forensic standards of practice.

Keywords: fire investigation, accelerant detection canine, accelerants, arson, fire, hydrocarbon dog, fire and rescue

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Introduction

Canines have been utilized by Fire and Rescue Services for the detection of accelerants since 1996.[2] The first operational accelerant detection canine (ADC) was introduced into the UK by West Midlands Fire and Rescue Service to provide a fundamental role within fire investigations. The purpose of a fire investigation is to determine the origin, most probable cause and development of fire.[3] Thus concluding if the incident was accidental, deliberate or natural. Fire investigations require the knowledge and skill of a competent practitioner within the field who can successfully conduct an investigation using a scientific and systematic approach. Within fire investigations, there is a three tier approach adopted by Fire and Rescue Services set out by the National Fire Chiefs Council.[4] This competency framework for fire investigations outlines each tier:[5]

i. Tier 1: Basic fire investigation undertaken by Crew or Watch Commanders who are already in attendance at the fire scene. Purpose to provide information through the national Incident Recording System, required by the Secretary of State.

ii. Tier 2: Intermediate fire &/or explosion incidents (non-terrorist) where the origin or cause cannot be easily established. If the incident involves a serious or fatal injury or is deemed to be suspicious, a multi-agency approach should be adopted.

iii. Tier 3: Complex fire &/or explosion requiring multi-agency input, may involve terrorist attacks.

Tier 2 and tier 3 incidents involve arson related investigations. Accelerants are typically used within arson scenes in order to rapidly increase the speed of spread or intensity of the fire. Accelerants can be difficult to detect amongst fire debris which is why many Fire and Rescue Services apply the use of a hydrocarbon dog to assist with the investigation.

This critical review will explore the background of arson, touching on the chemistry of fire, its use within the criminal justice system and statistical analysis of both primary and secondary fires, caused by arson. Existing literature will be assessed in this review to discuss the values hydrocarbon dogs bring to arson related investigations, considering; increases in success rates, their use within fire suppression efforts, the scientific method and the proposed limits and ignitable liquids they are able to detect. Drawbacks to their work will be emphasised throughout this review to highlight areas that require further evaluation and physical assessment, identifying new approaches to strengthen their processes. Comparative methods to accelerant detection will be discussed to heighten awareness of accelerant detection systems and their principles to arson investigations.

Discussion

The chemistry of fire

Fire is defined as 'a rapid oxidation process, which is chemical reaction resulting in the evolution of light and heat in varying intensities'.[7] There are four key components to the fire tetrahedron; fuel, heat, oxygen and a chemical chain reaction. Of all key components, oxygen (O2) is the most critical as it is vital for common combustion 8. The oxygen in the atmosphere reacts with the atoms in the fuel as it burns, producing heat and combustion products e.g. smoke and gases. This is known as the oxidation process. In order to extinguish the fire, one of the four key components must be eliminated. The most common method used within the fire service is eliminating oxygen to the fuel supply. There are many ways to isolate oxygen from a fire i.e. a carbon dioxide fire extinguisher or water. A Class B fire, involving flammable liquids, can be extinguished through the use of a carbon dioxide fire extinguisher as it causes the oxygen to get displaced from the fire and replaced by carbon dioxide (CO2). The carbon dioxide dilutes the concentration of the reacting species in the flame, which alternatively reduces the collision frequency of the reacting molecular species and slowing the rate of heat release.[9,10] A Class A fire, involving solid materials, can be extinguished using water, commonly used by the fire service, as the water creates a barrier between the fuel source and oxygen source, effectively smothering the fire and its heat supply.[10]

Fire development consists of four separate phases. Each stage has its own unique features that shows progression of the fire and gives an indication to its time frame.[11] These phases include:

i. Phase 1: Incipient ignition

ii. Phase 2: Growth

iii. Phase 3: Stead state

iv. Phase 4: Decay

Incipient ignition, also known as the pre-heat phase, is the stage in which the fire ignites, involving; heat, oxygen and fuel to form a chemical reaction, producing flames.[11] The flames give off extensive heat and hot gases containing soot, carbon dioxide, toxic gases and water vapours. As the fire rises, it draws oxygen in to support combustion. The second phase is the growth phase, focusing on the movement of the fire. As the fire spreads, it begins to introduce adjacent combustible items allowing hot toxic gases, pyrolysis products and toxic smoke to rise upwards, leaving a lower layer rich in oxygen. Once the lower layer reaches its maximum temperature, the fire will reach flashpoint, moving towards the flashover phase. In many fire investigation scenes, a line between the gas and oxygen layer can be observed on the walls, known as the neutral plane.[12] The upper layer will consist of soot deposition, whilst the lower layer is relatively clear. Flashover is an additional phase that may occur between phase 2 and 3. When the fire suddenly transitions from a growing fire to a fully developed fire, flashover has occurred. There must be a sufficient amount of heat release, ventilation and fuel in order for flashover to occur. It should be noted that not all incidents will involve a flashover phase if the fire did not become fully developed.[12] The steady state phase also known as the full room involvement, is the phase in which all material is exposed to the fire and the fire spreads evenly, burning at a steady state. This phase occurs due to the burning rate reaching its maximum potential, with little oxygen to progress the fire.[11] The final phase is the decay phase which sees the fire gradually come to an end. This occurs when all fuel sources become exhausted, and the oxygen levels drop below 16%. Open flames will begin to dissipate, and glowing combustion will be predominant. This phase can be critical as the fire can easily re-ignite with the reintroduction of oxygen.[12]

Arson

Arson is defined as 'the crime of maliciously and intentionally, or recklessly, starting a fire or causing an explosion'.[13] It is a triable either-way offence, contained in the Criminal Damage Act 1971. Arson is classified into subsections; Arson Endangering Life and Arson Not Endangering Life.[14] Arson 'Endangering Life' only requires the intention to endanger life but not to kill. No physical injury needs to occur, just the act of using fire to cause damage or destroy property whilst endangering life in the process. In addition, it requires a person to recklessly damage or destroy property with the knowledge it could endanger life, without lawful excuse. If there was a clear intention to kill or an individual was killed, the crime would be classified as murder (class 2) and the perpetrator could be sentenced to life imprisonment.[15,16] Arson 'Not Endangering Life' only requires a person to intentionally damage or destroy property belonging to another, without lawful excuse. If convicted, the perpetrator could receive a sentence of up to 10 years imprisonment 14. Within the UK, convicting an arsonist can be extremely difficult. The individual must be placed at the scene at the time of the crime, with sufficient evidence to prove involvement in the crime. Due to arson being classed as a 'serious crime' and carrying a sentence of maximum life imprisonment, evidence presented in court must be unambiguous. The National Criminal Justice Reference Service states that only 10 percent of arsonists are 'cleared' by arrest and only 1 percent of those are convicted.[17] On the 1st of October 2019, new guidelines were issued by the Sentencing Council stating judges and magistrates are to give clearer guidelines on handing down sentences to arsonists.[18] Arson causes big strains on the fire service due to an increased demand on resources. New guidelines will see courts take 'full account of the harm caused by offences' and to consider 'the economic and social impacts' on public services.[18] Judge Sarah Munro QC stated "the guidelines ensure that courts can consider all the consequences of arson and criminal damage offences, from a treasured family photo being destroyed to someone nearly losing their life and home in a calculated and vengeful arson attack".[18]

Arson statistics

Since 2014/15, there has been an increase in the rate of arson cases within the UK by 15%. The National Fire Chiefs Council stated that in 2017/18, the Fire and Rescue Services across the UK attended 213,782 fires, 108,024 of which were recorded as deliberate. That constitutes to 50.5% of all fires attended in the UK being recorded as arson.[19] It should be noted that not all arson incidents are recorded. The NFCC stated that Fire and Rescue Services are only being notified of 13%-26% of all fires that take place. This is due to a large amount of fires self-extinguishing or being put out by non-fire service personnel before they are required to attend. The number of arson incidents reported by Police is extremely low in comparison to Fire Service as the Police do not attend all fire related incidents. Figure 2 displays the number of arson crimes recorded by the police in 2009 to 2020.

Figure 1 Fire scene attended by Cambridgeshire Fire and Rescue Service 6.

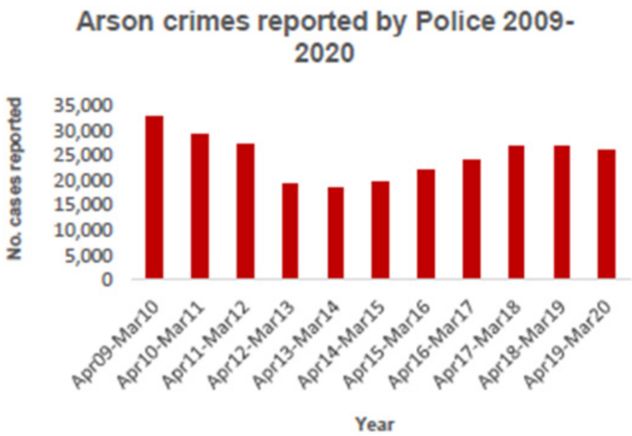

Figure 2 Graph reproduced from Police reported arson statistics published on Gov.uk 20.

Since 2009/10, the number of deliberate fires has decreased by a significant 44.3%. This can be observed in Table 1 which presents data on the number of deliberate fires attended by Fire and Rescue Services. Fire fighters and Officers have the responsibility to promote fire safety and arson prevention to the community. This is through a range of fire safety lectures, workshops, open days and campaigns.

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Although there is a reduction in the number of deliberate fires, it cannot be confirmed that the prevention work they provide has had an impact on this. As displayed in Table 1, primary fires was recorded as 34,714 in 2009/10. Fire Services across England saw a decrease in 2012/13 by 44%, with 19,432 deliberate fires reported.[21]

Table 1 Graph reproduced from Fire and Rescue Service reported arson statistics in 2019 – 2020 broken down into categories 21

Deliberate primary fires								
Year	**Total deliberate fires**	**Total**	**Dwellings**	**Other buildings**	**Road vehicles**	**Other outdoors**	**Secondary**	**Chimney**
2009/10	1,25,398	34,714	5,344	6,563	18,153	4,654	90,653	31
2010/11	1,16,812	29,470	4,893	6,065	14,635	3,877	87,321	21
2011/12	1,15,541	26,730	4,615	6,115	11,909	4,091	88,795	16
2012/13	68,760	19,432	3,626	4,278	9,099	2,429	49,309	19
2013/14	77,673	17,935	3,297	4,039	8,192	2,407	59,700	38
2014/15	68,521	17,366	3,013	3,829	8,203	2,321	51,133	22
2015/16	73,671	19,370	3,016	4,439	9,434	2,481	54,280	21
2016/17	76,148	22,066	3,105	4,582	11,826	2,553	54,066	16
2017/18	80,592	21,497	3,229	4,454	11,166	2,648	59,063	32
2018/19	83,246	19,778	3,033	3,640	10,259	2,846	63,440	28
2019/20	69,846	19,158	2,967	3,880	9,839	2,473	50,672	16

Primary fires are fires that occur in a building, vehicle or an outdoor structure. They involve casualties, fatalities, rescues and must be attended by 5 or more appliances.[21] Road vehicles have the highest recorded number of deliberate primary fires. The most common motives include; revenge, conceal another crime, civil disorder, insurance fraud, curiosity, riots and terrorism.[22] Concealment of a crime is a common motive i.e. burglary, drugs trafficking and murder. This is because the perpetrators want to destroy any evidence linking them to a previous crime. Vehicles can be difficult to investigate due to the natural presence of accelerants and ignition sources in a car that make it difficult to distinguish between accidental or deliberate.[22] In 2019/20, there were 9,830 deliberate primary fires to vehicles in the UK. This figure includes standard motor vehicles with the addition of bicycles, caravans, motor homes, minibuses and trailers. Out of those 9,830 deliberate fires, 10 incidents involved a fatality and 62 involved non-fatal casualties (Figure 3).[23] A secondary fire is a fire that occurs outdoors, in derelict buildings or involves the burning of rubbish and nature. As shown on figure Table 1, secondary deliberate fires constitutes to an extremely large portion of overall deliberate fires. However, between 2009/10 and 2019/20, there has been a decrease by 44.10%. Comparing figures, there is a difference of 62.19% between primary and secondary deliberate fires in 2019/20 in the UK.

Accelerant detection within arson investigations

The classification of an accelerant is 'a fuel or oxidizer, often an ignitable liquid, intentionally used to initiate a fire or increase the rate of growth or spread of fire'.[24] Accelerant is a term adopted by fire investigators to describe a substance used to fuel a fire, without inferring malice or intent. Many accelerants are hydrocarbon-based, also known as an ignitable liquid. An ignitable liquid is defined as 'any liquid or the liquid phase of any material that is capable of fuelling a fire, including a flammable liquid, combustible liquid, or any other material that can be liquefied and burned'.[25] Ignitable liquids are usually the chosen method to ignite a fire as they are cheap, readily available and volatile, making the liquid easy to ignite. Pouring and spilling accelerants with a direct flame is one of the most commonly detected forms of arson. As the temperature of the fire increases, ignitable liquids will vaporize quickly, but will not always burn. Liquids may remain at an arson scene if it was protected from flames or high temperatures, usually by absorbent materials. These materials include; carpet, plaster, soil, upholstery, untreated wood or cracks/crevices in flooring.[26] Table 2 presents data on the classes of ignitable liquids, examples of fuels for each class and their ignition temperature. The ignition temperature is the minimum temperature a substance should attain in order to ignite under specific test conditions.[25]

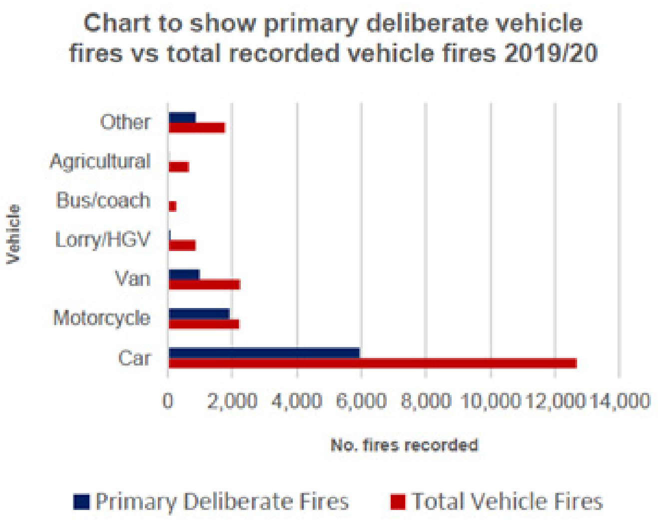

Figure 3 Graph reproduced from reported arson statistics in 2019-2020 21.

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Table 2 The displaying ignition liquids equals to accelerate a fire and their Ignition temperature[27]

Class name	Fuel	Ignition temperature
Light Petroleum Distillates	Petroleum Ethers	288 °C
Gasoline	All brands	Low Octane - 280°C
		High Octane - 456 °C
Medium Petroleum Distillates	Paint thinners	315 °C
	Mineral spirits	245 °C
Kerosene	No.1 fuel oil	210 °C
	Aviation fuel	210 °C
heavy Petroleum Distillates	Diesel fuel	210 °C
	No.2 fuel oil	257 °C
Additional	Alcohols	363 °C
	Acetone	465 °C
	Toluene	480 °C
	Turpentine	253 °C

Figure 4 Accelerant detection canine, Simba from LFB.

Figure 5 Metal paint can used for Arson evidence collection.

As part of a fire investigators job role at an arson investigation, they must collect and evaluate factual information and identify criminal activity to prove the offence. In order to determine the truth, they must complete a vigorous post-fire examination to determine the origin and cause of fire.[28] When arriving on scene, there is procedure that investigators adhere to. Before carrying out a physical examination, risk assessments must be completed to ensure the scene is safe to investigate, and statements must be collected from fire crews in attendance and witnesses to help visualise the fires behaviour and movement. In most cases, a cordon and common approach path are set up to minimise the number of people entering the scene. Investigators will liaise with the police to gain intelligence on the property and people involved.[29] Section 45 of the Fire and Rescue Services Act 2004 states that for commercial properties, a fire investigator may enter the building at any reasonable time to conduct a fire investigation. For a private occupied dwelling, permission must be obtained from the owner. If permission is not forthcoming, investigators must give a 24 hour notice to the owner of the property or fix a notice to the building.[29] If the investigation is deemed urgent, a warrant must be obtained from a Justice of the Peace to give permission to enter the property if it is deemed necessary, without using force.[29,30] When a scene is suspected of arson, there are a number of steps that have to be applied. Fire control must be informed and the police must be requested to attend. It is necessary in some circumstances that the Police hold a scene guard to protect the area until the duty Fire Investigation Officer is on scene. In most circumstances, Crime Scene Investigators will be requested to attend to assist the investigation. Once all necessary precautions have been applied, the physical examination will commence to locate the origin and cause of fire. Arson investigations pose extreme difficulties when attempting to identify the origin and cause of fire due to the destruction caused by the fire, compromising evidence. No matter how qualified and experienced the investigator may be and how diligent the search was performed, some cases simply cannot be resolved. There is a variety of methods to detect accelerants within an arson scene, some relied on more than others. In former times, olfactory detection was often used by fire investigators due to the lack of detection methods available. Olfactory detection brings many drawbacks, including the false perception of scents. The human nose is exceptionally subjective, causing the human brain to be misled into false reactions. The human nose becomes fatigued quickly, caused by continuous exposure to high levels of volatile fuels.[26] As a result, there are additional accelerant detection systems adopted by Fire and Rescue Services; e.g. canines and Photo ionization Detectors.

Canines and their success

Canines, also referred to as hydrocarbon dogs, have successfully been utilised by Fire and Rescue Services for over two decades. However, there is very little literature to their success and efficacy. In order to become a certified fire investigation dog, canines go through rigorous training for a minimum of three weeks, depending on the course and training body undertaken. It is vital that canines are able to work with heights, work in high risk conditions and be able to be deployed from a boat.[31] Depending on the fire service, dog handler units will be trained in different locations for different lengths of time. London Fire Brigades ADC's initial and CPD training is conducted at the MOD Police base in Essex, with one CPD day and a certification day held at the Fire Service College in Gloucestershire. In order to receive certification, canines and handlers must be able to demonstrate the following:[32]

I. Handlers ability to maintain full control of the dog during the exercise off the lead,
II. Ability of the dog team to perform an effective, systematic search of the entire search area, despite reasonable distractions encountered operationally,
III. Dogs safe/effective location and indication of the presence of an ignitable liquid for which it has been trained,
IV. Dogs ability to indicate ignitable liquid placed on test items,
V. Ability of the handler to recognise the indication of the dog.

Canines are specially trained to detect accelerant odour senabling traces of debris to be recovered for laboratory analysis to assist in the conviction of arsonists. Since canines were first introduced, their usage has increased dramatically within the fire service, with approximately 17 ADC units used in the UK to date.[31] One of the leading successes of canines is that their olfactory system is far superior to high-tech detection equipment**.** They are able to detect the presence of accelerants in minute traces, with a detection limit of 0.1 part per million (ppm) [0.1 microliter (μL) in a 1L can][26] in a sample. Often, traces detected by canines fall below the detection limit in crime laboratories.[31] Their strong sense of smell allows canines to discriminate between ignitable liquids within fire debris allowing large areas search to be completed far quicker, exceeding that of the human nose. A single investigation officer alone can search up to 20-30m² within four hours, whereas a canine can search between 400-500m² in approximately 10 minutes, therefore requiring less hours on scene. Canines also provide the benefit of less man-power required to complete a thorough investigation. This is because they can indicate to samples that need to be recovered for laboratory analysis, eliminating guessing work of sample collection. It is vital that canines are used for evidence collection at arson investigations as the 1995 study by Tindall and Lothridge confirmed that a positive alert by a canine gives a high probability that an accelerant is present, assisting with the increase in conviction rates. In addition, it enables less samples to be collected for examination due to pin pointing the exact location of the source, and locating areas where visible pour or spill patterns cannot be identified with the naked eye.[34]

As with all fire investigations, there is a scientific method behind it to ensure the methodology is robust. Systematic searches are adopted by fire investigation canine handlers as it allows them to stand back, assess the area and watch their dog's behaviour to identify any changes. Once behaviour changes have been identified, it is down to the canine handler to focus and 'clear' a room. Clearing a room involves close interactions with the canines to walk them around every inch of the area to locate the source. It is vital that the recommended methodology is applied as it forms the foundations for legitimate scientific and engineering processes.[35] This process is applied in the following sequence; observation, hypothesis, experimentation and verification. Those canine handlers with more than one accelerant detection canine such as Hertfordshire Fire and Rescue, can walk the scene with each canine to locate the source with similar alerts. Using multiple canines allows handlers to identify if there is an error with the canines ability to pick up a trace.

As a canine handler, one of their duties is to attend court as an expert witness when required, to provide evidence on the case using their knowledge and experience within the forensic field. Although the positive alerts by accelerant detection canines cannot be relied upon as proof in court, their assistance within the investigation is appraised nonetheless. In 1996, a Labrador retriever, Gus, examined fifty-four fire scenes, in which forty-three were ruled as arson. This demonstrates an increase in success from 10% to 80%.[36]

The cost for deployment of ADC's is far cheaper than using multiple technicians to investigate a scene and conduct instrumental analysis of evidence recovered. Although canines are referred to as a presumptive tests used in conjunction with laboratory testing, canines limit the number of samples required, therefore reducing time and cost. Each canine handling unit charges different rates per investigation. For an investigation outside of their county, they charge the attending fire service a set amount, i.e. £100 per hour. On average, the cost of a canine investigating an arson scene is approximately £280.[37]

Crowd searches during fire suppression is a benefit to canines as a means of accelerant detection. A common motive for arsonists setting fires is to attract attention to themselves and to feel powerful. As a result, one in three arsonists return to the scene in order to watch fire fighters attempt to suppress the fire. ADC's could bring value by searching the crowd to identify potential suspects who left traces of accelerant on their hands or clothing. Although this does not provide proof who set the fire, it sets grounds for police officers to identify potential suspects that need to be investigated.[34]

In England and Wales, it was established that all canine searches and the evidence obtained is admissible evidence in court, confirmed or unconfirmed. This was authenticated following the 1994 case of R v Pieterson. However, the ruling does not provide guidance on how the canines should alert, how the alert should be interpreted or its value. In 2011, Nottingham Crown Court considered evidence relating to unconfirmed alerts by canines in the Fiona Adams case. This case involved arson to a domestic property which resulted in the death of two children. The origin of fire was located inside the front door of the hallway on the ground floor. The canine alerted to the presence of an accelerant which was submitted for laboratory analysis. The result produced was negative giving an unconfirmed alert to an ignitable liquid. The negative result was not challenged by defence and the unconfirmed alert was accepted in court without any further legal challenge to its admissibility. This is because it was irrelevant to the defence argument and was admitted as evidence without regards to issues surrounding reliability and its value. Due to this case being heard in Crown Court, its binding precedent is limited and the case is not inconsequential.[38]

Disadvantages of canines

Although there are many benefits to the use of canines for accelerant detection within arson scenes, there are also disadvantages

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to be considered. Canines often struggle to discriminate between an accelerant and background materials. When common synthetic materials are burnt, they produce chemical compounds often contained in ignitable liquids. Volatile traces in carpet adhesives and insecticide sprays display similar odours to gasolines, which only proper laboratory analysis can identify the material.[26] Due to this, unconfirmed alerts by canines often arise. As a result, the National Fire Protection Association stated that canine's proper use is to 'assist in the selection of samples to be tested in a lab and recognized that unconfirmed canines alerts are improper evidence'.[33] This means, the evidence provided by canines cannot be relied upon during prosecution, and their use within arson investigations is merely a presumptive test rather than a confirmatory test. On October 25th 1994, a testing exercise was performed using [34] canines with the Canine Accelerant Detection Association (CADA) to examine the limits a canine can reliably detect and distinguish between background hydrocarbons.[39] The study stated that canines were alerting to samples that did not contain petroleum products, with almost two-thirds of canines alerting to un-doped samples during the common matrix test, and half alerting to samples not containing additives during the product testing.[39] It is believed some of the unconfirmed alerts were due to the handlers encouraging their canines that a sample was present subconsciously during scene examination. During the varied product testing, canines alerted to burnt carpet which produced sources of pyrolysis materials. Canines registered alerts to mixed matrix's and foam backing's which were present in 75% of samples without any added products. During Gas Chromatography analysis, significant levels of background compounds on un-doped samples were identified which the canines alerted to. This could be due the burning of synthetic/common materials producing pyrolysis components, often present in gasoline and other petroleum products, therefore triggering a false alert. Overall, the study states that practical limits for a reliable and successful alert by canines and confirmed by laboratory analysis lies between 0.2µL and 5µL for samples of gasoline containing background products. Lower limits between 1µL and 2µL of gasoline are deemed necessary for canine detection and laboratory analysis.[39] It should also be noted that canines may not indicate to an accelerant if they become distracted by another scent or have not been trained to detect it, leading to false negative results. In order to limit these issues, canines are trained to detect a wide range of liquids at varying volumes and trained to ignore distractions such as food and toys.[36]

A further disadvantage to canines as a means of accelerant detection is generalisation. Accelerant detection canines are trained to locate the source of an accelerant, not the scent. As a training mechanism, canines are rewarded with a tennis ball once they have located the source. However, it is possible they alert to a smell that is similar to that of an accelerant, in order to receive its reward. As a result, during rigorous training and CPD events, canines are not always rewarded with the ball for every alert, as it may lead to false detections. In addition to generalisation, canines may detect false positives due to its handler convincing the canine that an accelerant may be present. Canines should not be trained to look at its handler for reassurance in order to reinforce a detection.[37] In previous years, there has been issues with handler's beliefs influencing their canines by giving subtle/non-subtle cues to affect the canines alert. In 2001, a study was conducted to test the handlers influence on their canines during scene examinations. For this study, an indoor course was designed and handlers were informed that red markers around the building were indications to accelerant samples. However, there were no accelerants placed around the scene, in order to 'trick' the handlers into false detections. Eighteen handlers walked the course multiple times, in which 85% of the searches resulted in at least one alert.[36] This therefore shows that the handlers of canines can often have a negative impact of accelerant detection within fire scene examinations. Studies have also shown that canines are able to detect limits lower than the limits detected using instruments in laboratories. As a result, the sample being analysed cannot be confirmed and could therefore be recorded as a false positive. For judges that rely heavily on canine evidence, cases may be acquitted due to insufficient evidence, simply because the canines can detect limits lower than can be confirmed in a laboratory.

Handler bias is a further drawback as it may compromise the fire investigation, due to a lethargic scene examination. On April 21st 2001, James Hebshie was convicted of arson and mail fraud after he burnt down his convenience store, causing significant destruction. Sergeant Douglas Lynch was in charge of investigating the scene with his canine, Billy. He introduced Billy to the 'safe' area of the scene where he believed the origin of the fire was located. Billy alerted to a sample on the floor which was gathered for laboratory analysis. However no further contaminated or control samples were taken from the scene for comparison. The sample tested in the laboratory was positive for light petroleum distillates, which is a common material found in lighter fuels and glue, a common good which could be sold in Hebshie's store. Due to no further samples being collected for testing, the distillate could not be ruled out as the cause of fire. As a result of an improper investigation with insufficient evidence, Hebshie was granted a new trial.[40]

Vapour limits and air flow also causes issues for canines investigating arson scenes. Sources of ignition let out a vapour which can spread and cover a room. It is important that the investigation is conducted immediately in order to prevent contamination and to limit the vapour loss in the room. Over time, the scent on the source will fade and disappear, making it difficult to determine the exact location of accelerant application. Too much scent in a room can be just as bad as too little scent in a room. Too much of a scent can be overpowering, therefore overwhelming the canines nose, making it difficult to pin point the exact source. The vapours from the source will travel within a room, settle in corners and around furniture, causing canines to get confused and give false detections. When investigating outdoor scenes, the source of accelerant can be difficult to locate due to wind direction.[37]

The collecting and packaging of evidence often compromises the effectiveness of canine's accelerant

Collecting and packaging of evidence

The collecting and packaging of fire debris is an integral aspect within arson investigations. Volatile liquids must be protected and packaged correctly, in order to prevent evaporation of the sample. All arson evidence must be photographed, sketched, measured and described accurately before collection. For debris suspected of containing traces of accelerants, the sample should be packaged in one of the following materials:[41]

i. Clean and unused metal lined can – airtight and unbreakable. Sampling syringe can easily be inserted through the top of the can for sampling.

ii. Unused nylon or polyester bags – retains the lightest of hydrocarbons for a long period of time. The bags must be made specifically for fire debris analysis and should be doubled for evidence collection. It is important to note that nylon and polyester bags must be swan necked and fastened with string or a cable tie.

iii. Clean and unused glass jar – airtight and transparent to allow a visual examination prior to instrumental analysis. Rubber seals should not be used as volatile hydrocarbons can dissolve rubber closures.

The value of trace evidence can become compromised when cross contamination occurs during the collection of physical evidence. This is because laboratory equipment is extremely sensitive and can detect small traces of volatile liquids transferred by tools, gloves and boots. A new pair of gloves should be applied before each piece of evidence collection, to help prevent contamination. All tools should be cleaned using non-alcohol soap and water after each investigation. If the smell of accelerant is overpowering, large debris samples should still be collected. Comparison and control samples must be taken at every arson investigation. Comparison samples aid laboratory analysis and help to reconstruct hypothesis on whether an accelerant had been applied[41] detection results. Charcoal is an absorbent material which is commonly deposited during arson investigations and collected for analysis. Charcoal absorbs accelerants and therefore prevents a scent being let out, occasioning poor results by analytical equipment, and therefore not a representative sample of the scene. As stated by David Coss, East Midlands accelerant detection canine handler, the poor packaging of accelerant material has caused false results during analytical testing, providing inaccurate results. This is because heavily based hydrocarbons materials can evaporate through plastic but not nylon, whereas alcohols can evaporate through nylon and not plastic. Crime scene investigators commonly use two nylon bags to package accelerant materials, in preference to nylon and plastic packaging. Using two nylon bags can cause inaccurate analytical readings, diminishing the canine's ability. Canines are unable to give indications to which accelerant has been applied, thus plastic and nylon packaging should be used to limit vapour loss.[37]

A study in 2007 by Williams and Sigman determined that glass mason jars leaked more accelerant vapours over a period of time at 66°C than metal cans. Nylon packaging provided a slower leak rate.[41] A control air sample should be taken 10m from the affected building before entering in order to provide evidence that there is no accelerant in the atmosphere prior to entering the building. This will allow comparison to an air sample inside the building, to show if an accelerant had been used.[43]

Other methods to compare

Although canines are believed to be far superior to high-tech detection equipment, they are not readily available to all fire and rescue services when required. As a result, other methods for accelerant detection can be used. Photo ionization detectors (PID) are a portable vapour and gas detector which detects low concentrations of volatile organic compounds, carried by fire investigators and crime scene investigators. These concentrations range in ppm and ppb range. One of the benefits to using a PID during fire investigations is its non-destructive application. This ensures other detection methods can be used in conjunction with PIDs in order to confirm analytical results.[44] In addition, they are small and portable making it easy to transfer and can be used to detect volatile organic compounds in soil, sediments, air and water.[44] Compared to canines, PIDs are able to limit the alert towards pyrolysis products, reducing the risk of false positives. Although there are benefits to the use of PIDs, there are also drawbacks that question its quality. The detectors in the system are unsuitable to detect semi-volatile compounds. In addition, false positive readings can occur for water vapours. It is possible for rain to affect performance and high humidity's can decrease the sensitivity. PIDs are not sensitive to all common accelerants and can therefore provide a false negative, such as odourless charcoal lighter. Photo ionization detectors have to be re-calibrated frequently in comparison to canines in order to ensure they remain accurate. Although the detector has to be calibrated, it can be done on location in which the sensitivity to the monitored substance can be individually set.[44]

Conclusion

Accelerant detection canines provide significant advances in the fight against arson crime and provide substantial evidence in the prosecution against arsonists.[45] The literature discussed in this paper weighs heavily towards the success of canines and the value they bring to arson investigations. Due to their superior olfactory system, success rates of accelerant detection canines has risen by 70%.[36] Their ability to detect traces of accelerants should be utilised in all aspects, with an increased usage in crowd searches during fire suppression efforts,[34] saving valuable time, money and resources when identifying suspects. Positive alerts confirmed by laboratory analysis should be used as evidence during prosecution, [45] however unconfirmed alerts bring questionable disputes. Presenting evidence of unconfirmed alerts in court does not coincide with the modern day forensic science and standards of practice. As a result, canine evidence is not solely relied upon in court unless a confirmed positive result has been obtained by additional analytical techniques. Future developments will see an increase in success rates for prosecution against arsonists. Additional training in an attempt to limit false detections needs to be conducted, enabling canines to discriminate between background pyrolysis products and ignitable liquids. The use of solid phase micro extraction is a technique that should be adopted by more forensic laboratories, due to its high recovery rate of low volatile compounds.[46] Evidence consisting of ignitable liquids should be tested at the earliest time available to prevent evaporation of evidence, particularly with materials and clothing items.[47] Thus, providing an increase in ignitable liquid identification, increasing the success rates of canine recognition.

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Conflicts of interest

The authors declare that they haven o known competing financial interests or personal relationships that could have appeared to influence the work reported on this paper.

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