SUBJECT Analysis of Oil and Fat Residues from Kitchen Exhaust Ducts

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ISSUED BY Alexander Visotin, Laboratory Manager

Introduction

One of the services offered by our laboratory is the analysis of animal and vegetable oil and fat residues. This type of analysis is most commonly employed during fire scene examinations where self-heating oil is suspected of causing a fire and can reveal whether the oil had a high or low tendency toward self-heating.

A similar analysis can be of use when examining commercial duct systems. This Technical Bulletin deals specifically with kitchen duct systems, as these are most commonly associated with fire events due to build-up of oil and fat residues. Issues of liability are often prominent in such fires because questions arise regarding whether the duct system was properly maintained.

The fire scene examiner can often examine the duct system and note any build-up of debris. Samples of debris can be submitted to the laboratory for analysis. This analysis can determine whether the debris in the duct is chemically consistent with oils and fats such as those used in cooking. Analysis of duct debris that is found to contain oil and fat residues can support an examiner's opinions regarding the origin and cause of the fire, just as the observation of an ignitable liquid trail at the fire scene can be supported by a positive laboratory test.

Creation of duct debris

Duct systems are installed in order to evacuate vapours from cooking activities away from the kitchen area and appliance operator. Oils and fats in cooking ingredients, when heated, will liquefy and atomise. These vapours are then carried by negative pressure through the duct system. As they cool, they begin to resolidify, attaching themselves to the exhaust canopy, filter media, and duct interior. The solid, greasy substance that gathers in ductwork is an altered form of the original oil or fat and is combustible. Build-ups of this substance are often a significant fuel load in a fire.

The constituents of this grease depend on the cooking appliances that the duct services. Higher cooking temperatures will generally create larger volumes of oils and fats, thereby increasing the amount of grease in the ductwork. Charbroiling appliances, for example, will create significant amounts of oil and fat vapour, while cooking on a simple stovetop grill will produce only small volumes. The type of cooking will also influence the duct debris content. Solid fuel cooking can create creosote and ash, which combines with oil and fat vapours and adds to duct debris volume. Deep fryers create grease with a shiny appearance that solidifies strongly. Wok grease from Asian-style cooking creates thick, syrupy grease similar in consistency to caramel.

p. +61 2 4628 6420 f. +61 2 4628 6440 e. admin@gkaig.com.au PO Box 612, Campbelltown NSW 2560 AUSTRALIA
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The resultant grease build-up in the ductwork can range from liquid pools, to light and fluffy residues, to thick, solid deposits that bake onto the duct surface. After a fire, these deposits turn into a black, carbonaceous material that can usually be sampled.

Fig 1. Liquid residue build-up.

Fig 2. Oil and fat deposits that have been fire-affected.

Cooking flare-ups often cause fires in duct systems when heat or flames generated from the cooking appliance start a larger fire in the duct system above. The potential for oil and fat residues in the duct to ignite depends on their moisture content, depth, position and oxygen supply to the duct. The fire examiner can make these observations during their scene examination.

Sampling of duct debris

Sampling of oil and fat residues should be approached in the same way as sampling of ignitable liquid residues. Oils and fats degrade over time and with exposure to heat, thus the objective of sample selection is to reduce the effects of these variables as much as possible.

Samples should not be taken from the most significantly damaged areas of the duct system. Any deposits left at the point of the fire's origin are unlikely to contain detectable concentrations of oil or fat residues, as they are likely to have been consumed. If the debris in the duct is thick, hard, and difficult to remove, this generally indicates that the sample will be of poor quality.

Ideally, samples should be taken from areas of the duct that the fire has not become fully involved in. While ignitable liquids may only be present in the immediate vicinity of an accelerated burn area, requiring sampling close to the fire's origin, oil and fat residues are carried throughout the duct by negative pressure, such that grease build-up is generally more uniform throughout a duct system. Therefore, a sample can be taken some distance away from the origin of the fire and still be considered a representative sample.

Debris that can be removed easily by hand that appears fluffy, wet, or otherwise like loose sand or dirt, is often a good candidate for sampling. This indicates that the grease has not polymerised due to heat exposure and may contain detectable levels of fatty acids. Liquid residues are the best material to sample, as they will be the least affected by weathering, but may not be present in a severely fire-affected duct system.

It may help to consider the example of ignitable liquids deployed onto a timber floor. Sampling the charred, mostly destroyed floorboards in the centre of the hole in the floor is unlikely to yield a positive result. However, a sample obtained from the perimeter of the burned area where the liquid remains trapped in the wood grain is more likely to yield a positive result. The same logic applies to duct debris samples.

Fig 3. Hard, solid, carbonaceous debris such as this would likely be a poor candidate for sampling.

Fig 4. Light and malleable debris that can easily be removed from the duct by hand is a better potential sample.

The same precautions taken for typical animal and vegetable oil sample collection and storage should also be employed when collecting duct debris. The fatty acid composition of oil and fat residues will change as they oxidise. Oxidation occurs continually until the residues polymerise, at which point analysis is unlikely to be successful. Samples should be packaged into airtight containers such as metal tins. Samples should be kept refrigerated whenever possible. Prompt analysis is required.

Analysis of duct debris

Extraction and analysis methodology is the same as that employed for typical animal and vegetable oil residue (VOR) analysis. As oils are far less volatile than ignitable liquid residues (ILR), they are not captured as readily by the same adsorbents used to extract ILR. As a result, headspace-based extraction techniques are not effective for VOR extraction. Oil and fat residues are more efficiently removed from debris via solvent extraction and filtration. This creates a liquid extract, which can potentially be analysed via gas chromatography-mass spectrometry (GC-MS).

Unfortunately, the triglycerides that make up animal and vegetable oils and fats are not readily analysed by GC-MS. Instead, the extracted sample must undergo a derivatisation procedure whereby the trigylcerides and free fatty acids in the sample are converted into fatty acid methyl esters (FAMEs). FAMEs can be detected via GC-MS more reliably.

With typical VOR analysis, the aim of analysis is to ascertain whether or not an oil or fat residue has a high or low tendency toward self-heating, based on the number of polyunsaturated fatty acids detected. This is not usually a significant question when analysing duct debris, as an external ignition source (such as a cooking flare-up) is usually responsible for the fire. Instead, duct debris analysis focuses on whether or not the oil and fat residues in the sample are consistent with oils used in cooking. This can be confirmed by the presence of fatty acids common to cooking oils such as olive, canola, and sunflower oil.

If a comparison sample of the liquid oil used in cooking can be obtained, this can potentially be used to confirm the identity of the oil and fat residues in the duct debris. However, this conclusion is often made impossible due to the presence of other oils and fats from food items being cooked. Weathering of the oil and fat residues in the duct also takes place as they oxidise. Analysis conclusions are based on the condition of the debris *after involvement in a fire*, where significant thermal degradation may have occurred. As the fatty acids in duct debris oxidise, the ratios between saturated and unsaturated acids will change. These ratios can change to a point that the original oil is no longer identifiable, or no oil or fat residues are identifiable at all. For these reasons, proper sampling technique is important.

Instead, analysis results can usually support the hypothesis that debris in the duct was consistent with grease build-up from cooking activities, as opposed to the build-up of dirt or other matter. This can be significant when the cleanliness and general maintenance of the duct system is under question.

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