NORDIC FIRE MANUAL

A practical guide for fire investigations

Ver. 2.0 | First Edition

A collaboration project between the Nordic countries

PREFACE

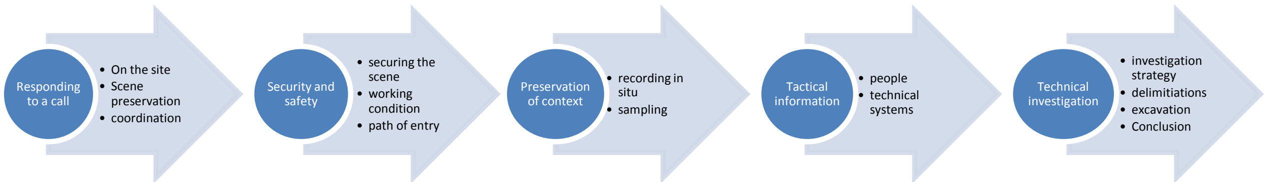
This guide replaces previously published manuals created in 1997-2000 and revised in 2009-2010. Besides the earlier versions, this guide is also based on ENFSI`s *Practical guide for fire investigators and specialists in fire and explosion investigations*, and is the result of a collaboration of experienced fire investigators from the national forensic units in Finland, Iceland, Sweden, Denmark and Norway. Representatives from the Danish institute of fire- and security technology and Southwest Finlands Emergency Services have participated as well (see attached contact list). The main guide will be in English, though each of the countries will make some national adjustments to their national guides.

The practical guide is for fire investigators and specialists, with recommendations for how to conduct an investigation at the scene of a fire in order to achieve the best possible results. This guide brings together currently available information, and is the result of an extensive study of the best practice applied in the Nordic countries. It should be used in conjunction with other reporting guidelines, and in accordance with procedures required by your national authorities, for instance health and safety instructions.

Each fire presents new challenges, and a fire which initially seems simple, may well turn out to be so complicated that the assistance of a specialist will be needed. It is important that we know our limitations and request assistance from a specialist rather than risk making mistakes and be responsible for a miscarriage of justice or for failing to identify a crime due to an inaccurate or incomplete investigation.

Many years' experience has taught us that, in order to carry out a sound fire scene investigation, we should proceed in a specific order, from the arrival of the first responders to subsequent laboratory analyses. This guide outlines the most important steps that should be taken by the fire investigator in order to ensure that subsequent examinations can be carried out effectively. It is essential that we follow a systematic approach in order to perform our role correctly and safely.

This guide provides information for fire investigators, in order to ensure that pieces of information are not lost. It covers five phases of activity and, for each phase, the role of the fire investigator is explained. The different phases should not be considered independently of one another and, during some investigations, they need not follow in the same order. They are interwoven and the activities of each phase tend to overflow into the next.



People involved in fires and fire investigations belong to one of the three categories of involvement that all take part in determining the origin, cause and development of a fire. The boundaries between the categories are not clearly defined.

Definitions of types of involvement (for details, see *Appendix 2 Investigation phases*)

Name	Definition
First responder	The first official person who responds to the incident (e.g. police, fire department).
Fire investigator	People who are called in by the officer in charge of an investigation when the fire investigation is considered to be more complex.
Specialist	People who have special competence or knowledge, combined with specific expertise and experience in their chosen field. The specialist is called in by the fire investigator.

CONTENTS

1. FIRE INVESTIGATOR AND SPECIALIST

1.1 - Requirements and standards

The fire investigator and the specialist must have the qualifications, i.e. relevant education and experience that are relevant to the task at hand. A conclusion will qualify as scientifically established if the fire investigator/specialist can demonstrate that it is the product of sound scientific method. The scientific method is the process of systematically gathering data, formulating hypotheses and then conducting experiments and analyses to prove or disprove them, see *6.10: Final hypothesis and conclusion.*

1.2 - Allocation of responsibilities

All activities - involving scene preservation or the protection/recovery of potential evidential material - should be communicated to the appropriate officer as soon as practically possible. If assistance is required within a given discipline, expert advice must be sought. The following is a list of the kind of expertise that *could be* needed at a fire scene investigation:

- From a forensic laboratory
    - Chemical analyses
    - Osteology
    - Electrical, gas and mechanical investigations
    - Fire protection engineering analyses

- From the fire and/or rescue service
    - On-site fire investigation.
    - Risk assessment of fire spreads
    - Fire protection engineering analyses
    - Investigation of heating appliances and chimneys

- From the national safety board (for example electrical and gas safety)
    - Fire investigation at the scene
    - Investigation of heating appliances and chimneys

- From a medical examiner or forensic pathologist/odontologist
    - Identification of bodies
    - Medical examination of suspects
    - Determine cause of death

- From the national maritime administration
    - Risk assessment of fire propagation on ships

A multi-disciplinary approach gives the best results if we want to uncover all available physical evidence, determine the identity of any deceased persons and the origin and cause of the fire.

One or more of the following professionals will often be involved in the investigation of a fire scene:

- Forensic fire investigator
- Forensic electrical engineers
- Local fire department
- Forensic locksmiths
- Forensic motor vehicle examiner
- Representative from insurance company

2. RESPONDING TO A CALL

The fire investigators are not normally directly involved in this phase of an incident. They should ideally retrieve a written report from a first responder and liaise with him or her to obtain information, before arriving at the fire scene. See appendix 2: *Investigation phases*.

2.1 – On the way to the scene

We request and record information:

1) The call-in time of the initial fire report(s) and any information given by the caller(s)
2) People present (witnesses, bystanders, reporters, others)
3) Vehicles present
4) Persons leaving the scene
5) Strange activities
6) Weather conditions (wind speed and direction, changes in weather).

On our arrival, we record:

1) Our own activities (safety assessment, evacuation or rescue of personnel, and fire suppression)
2) The activities of fire fighters.
3) Contact details of bystanders, particularly if they seem conspicuously interested or behave oddly, or if they have been taking photograph
4) Reactions of the owner when he/she arrives

2.2 - At the scene

Start collecting information from the rescue service commander and the fire fighters. We often obtain valuable information from witnesses and the property owner, particularly at an early stage. It is important that we secure the electronic logs of alarm systems and CCTV footage, because this evidence may be lost if there is a power failure.

When we arrive at the scene, it is a good idea to sketch a timeline; when the electricity supply was broken, when any explosion occurred, when any window was broken and we photograph and/or video-record any intervention carried out by the emergency services, such as drilling, etc.

We take photographs and make notes as soon as possible. Photographs and notes should cover all angles and aspects of the site, including areas which may not be on fire at the time. We take photographs of firefighting activities, paying particular attention to the location of smoke and flames. Video-recordings are also useful. We need to make sure that recordings are timestamped, and that the camera's (and video-recorder's) clock is correct.

We should always cordon off the fire site and surrounding areas.

2.3 – Scene preservation – preliminary steps

Any modification to the scene before the arrival of the fire investigators must be recorded and well documented.

It is important for all fire scene investigations that no objects within or outside the site are moved unnecessarily. While it is recognised that fire suppression activities will result in the movement and/or damage of some objects (e.g. doors and windows to gain entry), removal of any objects from the site must be minimised. Any items which do need to be moved or removed should be photographed (with the time and date) beforehand, and the action should be logged.

Some evidence is not always visible to the naked eye (e.g. DNA, foot- and fingerprints) and can have been left at the scene by first responders. Appropriate anti-contamination precautions (e.g. the use of forensic scene suits, gloves, masks etc.) must therefore be taken where appropriate.

2.4 - Communication and coordination

The first responders and the fire investigators at a scene may contact each others for advice regarding the scene . Such advice may concern what people to speak to and what kind of information will be required at a later stage.

All investigation work at the scene needs to be coordinated with and communicated to all parties concerned.

3. SECURITY AND SAFETY

Strict surveillance and security measures must be put in place and maintained before, during and, if necessary, after the fire investigation.

3.1 - Securing the scene

In order to ensure the integrity of the scene, we make sure that a sufficiently large area is cordoned off. If this has already been done, we consider whether the cordon needs to be increased or if it can be reduced. We also consider whether to use both an inner and an outer cordon. The outer cordon must be sufficiently large to encompass all areas containing possible evidence. As few (and only authorized) people as possible have access to the area inside the cordon.

3.2 - Safety and working conditions

The fire investigators should make their own on-site risk assessments, and should realise that they are responsible for their own safety as well as the safety of those around them. The outside area should be assessed for risks and hazards. These include (but are not limited to) the structural safety of the building (mechanical aspects, electricity, roof, walls, the presence of sharps such as glass or other debris etc.). If necessary, specialist advice should be sought.

An examination may have to be delayed until the structure is deemed safe enough to enter. Actions to make the structure safe may involve supporting or demolishing walls, floors, and/or the roof, use of scaffolding, etc. Sufficient lighting must be available; - ideally battery powered lamps shuld be used. If a petrol/diesel-driven electricity generator is used, we do not refuel the generator at the site, and take care where we place it to minimise potential contamination. We always use disposable gloves (which must be left outside the fire scene).

Risk assessments must be dynamic, and they need to be repeated after any change to the structure.

Other aspects and potential hazards that have to be logged include: information about the mains electricity, the presence of any gases, asbestos, chemical hazards and other aerosols and the risk of secondary explosions. We can get valuable information from the property owner about any potential hazards.

Such information has to be communicated to all personnel on site and to any specialists/experts and others upon their arrival. See also appendix 6: Work environment.

3.3 – Security adjustments

Cordoning off the area with tape, alone, is not an efficient way to preserve a scene. Barrier tape will usually keep the general public away, but cannot prevent entry altogether. To this effect, a human presence (police officer or security guard) is needed at the cordon and should be maintained until the examination of the fire scene is complete. If this is not possible, the absence of a ‘scene guard’ must be recorded.

Ideally, for reasons of health and safety and to help establish a timeline of the events, the person guarding the cordon should keep a scene log, recording the time of entry and exit of all persons to and from the site, including his/her own.

3.4 - Path of entry

Our access route will depend on the type of incident. However we should decide on a route, before we clear and mark the path. We should make sure this access route is used consistently by all personnel entering and exiting the area.

4. PRESERVATION OF CONTEXT

4.1 - Dialogue with the first responder

The first responder may have contacted the fire investigators before arrival at the scene. We recommend that they try to preserve the fire scene, i.e. the evidence. In some situations, the enquiry will focus on how to move and preserve potential evidence. If any items are moved from their original positions, this must be recorded.

On arrival, the fire investigator should liaise with the first responder to determine whether anything that may constitute evidence has been removed, altered or preserved. It is important for any further investigation that all activities be recorded and that this information be passed on to any subsequent investigator (see appendix 2).

Such information should include:

- Breaking of doors or windows
- General and specific firefighting activities
- Activities after the fire has been extinguished

4.2 - Recording in situ

As part of the initial examination of the area, a series of panoramic photographs and/or videos should be taken. In addition, the fire scene should be sketched. Even in rooms that are undamaged, we take photographs and notes.

Exterior documentation should describe landmarks that will help identify the exact location of the fire scene, e.g. adjacent buildings or other structures, and include photos from various angles outside the scene. Images from various viewpoints and series' of sequential photographs can be used to contextualise different areas of the fire scene. A collage of photographs can be useful if a wide angled lens is not available.

360^o photography, drones, 3-dimensional recordings and scanning techniques could be included in the recording process. We must always keep in mind that pieces of forensic evidence may need to be protected and recorded prior to removal, e.g. fingerprints, glass, tool marks, footwear and tyre marks, fibres, blood (including blood patterns), DNA, etc. All photographs taken should be stored in accordance with local regulations and/or national laws.

4.3 - Sampling

4.3.1 - Overview

The technical examination of the fire site depends on preservation of all tracks and objects in and around the area. Evidence should be secured as soon as possible so that traces such as shoe prints, tire prints, cans, etc. are not destroyed or removed.

We should always bear in mind that other forensic investigations may also be needed, e.g. of weapons, fingerprints, fibres, blood etc. All our work should be carried out according to relevant guidelines. Found matches, cigarette butts, candle remains, candle wicks, night-light (tea light) holders, wick holders etc. near the point of origin may be of interest when the cause of fire is to be determined through hypothesis testing. For specific packaging requirements, we consult the most recent instructions in our jurisdiction. All these activities should be coordinated and documented on the scene.

Samples shall ideally be examined by a certified specialist/expert. We may also need to collect items such as bedding or furniture for examination. It may be a good idea to request advice about what and how much to collect from a specialist/expert. Samples should not be destroyed without authorisation, because they could be required for further examination or use as evidence.

It is important that we promptly secure the electronic logs of burglary and fire alarm systems (smoke detectors). There may also be CCTV footage. Such electronic evidence may be lost if there is a power failure.

For all sample and secured material or effects, we carefully record where it was found. Each object must be labelled with the file number and a unique number. The securing of materials must also be in accordance with the national guidelines. Also see NFPA 921, Ch. 16.

4.3.2 - Ignitable liquids

Arson often involves the use of accelerants, notably ignitable liquids such as gasoline, white spirit, lighter fluid, heating kerosene and diesel. Bear in mind that although ignitable liquids are detected, this does not automatically mean that the fire was started intentionally. The presence of ignitables may be due to contamination or legal storage, or the substance may have been brought in subsequently.

If there is any suspicion that an ignitable liquid has been involved in the fire, suitable material samples should be preserved in appropriate containers. Samples should be taken:

- From places where the liquid might have been protected, e.g. behind skirting boards, under thresholds etc.
- From the outer edge of a much burned area, floor and wall insulation, cracks in the floor, floorboards etc.
- From items into which liquid may have been absorbed by capillary action e.g. flat surfaces such as table tops or the bottoms of drawers, carpets etc.
- From below windows, both indoors and outdoors.
- From places where the fire pattern indicates that ignitable liquids have been used

Electronic sniffer devices and hydrocarbon dogs can be used to locate the best areas for collecting samples for ignitable liquids.

It may be appropriate to take a reference sample. Some materials, such as various kinds of plastic foam, rubber mats and ink, may contain substances that resemble ignitable liquids, and need to be compared with reference samples before any conclusion is drawn.
To avoid cross-contamination, we carefully clean tools between each sample, and use disposable gloves, changing them as required. We need to be alert to other sources of potential contamination, e.g. petrol-driven machines which have leaked fuel or oil, and additives in some extinguishing foams or waters. For the same reason we are particularly cautious when handling a petrol-driven electricity generator at the scene. We certainly do not refuel it there, and we use disposable gloves that should be kept off the scene.

4.3.4 - Hydrocarbon dogs

Specially trained dogs can be used to search a fire scene for residues of ignitable liquids. It is important to keep in mind that the dog only gives an indication of where the sample for analysis can be collected. If a sample taken from an area indicated by the dog tests negative, we do not refer to the dog's selection as evidence that there were ignitable liquids at the location. A dog's nose is many times more sensitive than an analytical instrument and can sense amounts that are smaller than what we define as a "positive finding".

If an interpretation of fire damage indicate that the fire has started at a certain place, and the use of ignitable liquids is suspected, samples should be taken and tested, even if the dog has not indicated ignitable liquids. A report should be written for each request to the laboratory, indicating what areas have been searched and the number of secured samples.

4.3.5 - Packaging - ignitable liquids

Most ignitable liquids evaporate easily. The evaporation time will depend on the substance, the ambient temperature, the surroundings' absorption capacity, and other atmospheric conditions. The samples therefore have to be collected as soon as possible when the scene is safe to enter. Fire residue that is suspected of containing ignitable liquids must be packaged as recommended by the analysing laboratory. We label all samples carefully so that there is no doubt as to where they were collected. If fire debris bags are used, they must not be so full that they cannot be sealed, and must not contain sharp objects that could perforate them during shipment.

We always need to keep in mind the risk of contamination between samples during shipment. If not properly stored, fire debris bags could be contaminated by ignitable liquids in the immediate sorroundings (in a storage room, car or laboratory) even before they are used. One way to store fire debris bags is to put some bags in another bag, which is then heat sealed. To check whether the bags are contaminated, a reference bag can be sent to the laboratory. Clothes from deceased persons and suspects have to be shipped separately.

4.3.6 - Bottles and cans

The contents of bottles and containers found on the scene need to be sent to a laboratory for analysis. Even a seemingly empty container needs to be analysed since it could contain traces of an ignitable liquid. We need to bear in mind that there may be fingerprints or DNA on the container. Containers with liquid should be sealed and sent as they are, unless the contents are decanted into an appropriate container. If we want only a small sample of the liquid, we use a clean pipette rather than pour the liquid out of the container. To avoid contamination, we sample or decant liquids outside the area of interest.

4.3.7 - Electrical systems

At best, a specialist examines all technical systems on site. If this is not possible, specialist advice should be sought. Electrical equipment, in particular, should be examined on site. If objects require further examination in a laboratory, they should first be checked on site by the person who will examine them in the laboratory, or by an electrician with the proper expertise, who can provide a description of the electrical installations and the circumstances surrounding the fire

If electrical equipment, including cables showing signs of short circuiting or arcing, are sent for further examination, they need to be accompanied by photos or sketches, taken before they are dismantled and packaged. The photos or sketches should clearly show the extent of the damage around the equipment. The following can also be useful; drawings of the electrical installations, information about any operational problems, about whether the equipment was being used during the fire, or about when it was last used, as well as about any bypassed fuses and circuit breakers.

If an examination is needed of, for example, circuit breakers or electric switchboards, etc., and if they are heavily damaged by fire, they should preferably be recovered together with a portion of the substrate to which they are attached (the wall, the floor etc.). We make no attempt to separate the one from the other, and we indicate the orientation (up/down). The positions of switches, thermostats etc. must not be changed. In the case of electrical appliances, such as dishwashers, washing machines, cookers, coffee machines, we submit the whole apparatus without touching switches etc. If the appliance is plugged in, we take the plug as well.

4.3.8 - Living People

The officer in charge of an investigation will need to decide whether to search for evidence on a suspect. The fire investigator and the specialist should be able to offer advice about evidence recovery and packaging. A suspect's clothing and shoes should be seized and packaged with a view to preserving any ignitable liquid traces as soon as possible. Clothing and shoes may need to be inspected under a microscope if we are to determine whether they have been subjected to flame-wash or high temperatures, so the entire garment should be brought in if possible. The samples are transported and packaged depending on the nature of the required lab tests. Moreover, if samples from hands are required, we need to use suitable gloves or absorbent material, depending on the procedures of the analysing laboratory.

Burns on a suspect's body should be documented with photographs. A medical examiner inspects the suspect as soon as possible to check for burns and to see whether the hair on his/her hands or head, or his/her eye-brows, eye-lashes or beard are scorched. Samples may be taken for further examination.

Other forensic evidence that may need to be preserved includes glass fragments, fibres, blood and other biological evidence.

4.3.9 - Documents

If we need to seize documents found during an investigation, we carefully place them between stiff sheets of cardboard and use suitable packaging. Damp material should be sent for examination as soon as possible.

4.3.10 - Biological and chemical spontaneous combustion

If we suspect that spontaneous combustion started the fire we need to take samples from the point of origin and also from less damaged areas where there might be self-combustible material. We may want to contact a specialist for further advice or to request reference samples and additional tactical information.

We need to find out and record what working procedures were normally followed, and deviations from or changes to them. If there are undamaged remnants of a recently applied product, we take samples for further examination. What temperature was the product normally exposed to? Where there any strange smells before, during or after the fire? Samples of substances suspected of causing chemical spontaneous combustion must be packed in fire debris bags. If biological self-ignition is suspected, the samples need to be preserved in paper bags in a cool (preferably refrigerated) place until they can be submitted for examination. Such an examination should be conducted as soon as possible, since biological (e.g. bacterial) conditions in such samples tend to change.

4.3.11 - Packaging and removal of fragile items

If items need to be removed from the fire scene immediately or are likely to become damaged, their original positions should be photographed and documented. We need to show the exact location of each item in the building, vehicle or area from which the item was taken. Sampling should be carried out as described in Chapter 4.3

Once removed, the item needs to be packaged appropriately and disturbed as little as possible. It has to be stored carefully before being signed over to the laboratory, so as to be subjected to a minimum of damage and contamination.

4.3.12 - Maintenance of sampling equipment

Each country will have established detailed instructions about the maintenance of sampling equipment, including when and how to clean it, and when to use only disposable gear. The manufacturer must specify product lifetime and recommended cleaning schedules.

5. TACTICAL INFORMATION

At the site, the fire investigator or specialist might encounter one of two situations :

1. Fire propagation has been limited, and it is therefore quite easy to locate the origin of the fire.
2. Property has been severe or completely destroyed. Extensive excavation may be required to determine the origin of the fire.

The information gathered by e.g. the police officer, the fire department and the first responder will be of use in both of these scenarios.

Tactical information can be grouped into two categories: information from people and information from technical systems. See *Appendix 3 Tactical information*.

5.1 - Information from people

We read the report written by the first responder. If it has not been completed, we try to obtain what is missing, such as photographs, videos and/or plotted sketches (made with, for instance, a whiteboard plotter). Additional enquiries should be recorded. New questions tend to arise in the course of an investigation. It is therefore a good idea to invite the rescue service commander and fire fighters to return to the scene of the fire, and discuss their observations and actions with the fire investigator.

It is important to obtain information from the property owner and/or the last person that was present before the fire started. It may also be useful to make enquiries among witnesses, and ask whether they have any pictures or videos from before or at an early stage of the fire. Social media can also be an important source of information. And of course, we draw up a timeline for what happened before, during and after the fire.

5.2 - Information from technical and electronical systems

Is there any technical system that can provide information ? Is it connected to a remote call station ? Logs from call stations might include data from individual detectors, that can help the investigator map the spread of the fire. Some information may be time-dependent. Recovery of CCTV footage and information from alarm-systems needs proper authorisation. Some examples of information from technical systems:

- Drawings and plans of gas pipelines and storage, electrical grids, structural information about the building.
- Details about specific electrical devices or appliances
- Process information and standard operation procedures
- Alarm logs, maintenance logs, power consumption logs, internet logs etc.
- Licences and manuals about equipment
- Regulations and standards (new, old)

6. TECHNICAL INVESTIGATION

6.1 - General

A risk assessment for personal safety will always be performed before the examination is launched.

An inspection of the site should be carried out after the fire has been extinguished and the work environment is safe. The whole area must be inspected, and the fire damage as well as the fire pattern is assessed and observed before any fire debris is moved.

As part of the initial on-site examination, we take photographs and, if it seems advisable, make video recordings. Correct documentation and photography is essential. Multiple views and sequential photographs from several angles can be used to highlight different areas of the scene (for details se Chapter 4.2: *Recording in situ).*

Documentation should also include a log of our observations and actions. All these documents should be signed, dated and stored in accordance with local regulations and national laws, so that they can be retrieved and reviewed at a later date.

6.2 - Interpretation of available information

During a fire investigation we have two primary goals. We want to determine:

- the point/area of origin (where the fire started).
- the cause of the fire.

All technical investigations should primarily consider the physical evidence. We should treat witness information with caution as it could be incorrect or misleading.Was it really possible for the witness to observe what he claims to have seen from where he or she was standing?

To optimize the quality of his/her interpretation, the fire investigator will apply scientific method in combination with (when called for):

- examinations of the fire scene
- validated analyses
- triangulation of technical methods (e.g. hydrocarbon dogs, lab tests, fire experiments)

6.3 - Investigation strategy

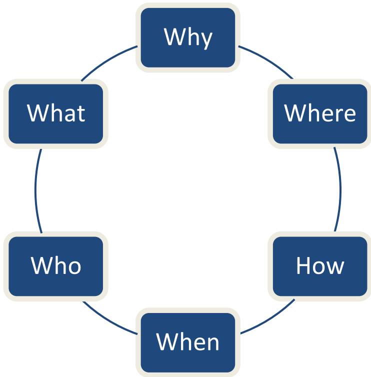
An investigation plan is made as early as possible. It is of the essence that we are familiar with all known circumstances relating to the fire before we enter a burnt structure. We request this information from the first responder(s), fire fighters etc. Starting with insufficient information tends to yield poor results and accidental destruction of evidence. See *Appendix 2: Investigation phases.*

It is highly advisable to work in teams. The size and configuration of each team will depend on the nature of the site. At least two fire scene investigators should be present on the site itself, so that they can support one another and prevent one another from taking a subjective approach. They have to be comfortable with the kind of work they are carrying out and should call for assistance if necessary.

Fire investigation is a scientific process in which a systematic approach is taken to answer specific questions relating to the fire, its development and its cause. It is carried out by means of detailed examination of the site, and collection and recording of data. The information gathered is analysed on the basis of the investigator's knowledge, experience and expertise. The investigator will develop multiple hypotheses. It should be possible to test these hypotheses and they should be robust. The outcome must be an accurate understanding of the origin, cause and spread of the fire.

A fire scene investigation must cover the following points:

- Establishment of the seat of the fire - WHERE
- Establishment of the fire's cause – WHAT
- Establishment of the fire's development - HOW and WHEN



The technical investigation focuses on the above and contributes knowledge, if possible, to the tactical investigation, i.e. WHO and WHY (the motive).

6.4 - First inspection

To form a picture of how a fire started, we need to get an overview of the area as soon as possible.

Our first inspection should give us a rough idea of where the fire started. Here we must emphasize that our first impression is preliminary only, and serves as a basis for deciding where to perform the first excavation. If we determines where the fire started already at this stage, we will do so only on the basis of information from the extinguishing phase in combination with testimonies from witnesses and our own initial observations. So it is important not to be too specific and to keep an open mind. It is far too tempting to rely on a idea, and to continue defending it throughout the investigation.

It may be easier to see how the fire spread and where it penetrated through the roof from a higher vantage point. A higher vantage point can be obtained with a drone camera, lift etc.

We try not to move anything when we study the damages and fire patterns (see NFPA 921, Ch. 6).

6.4.1 - Surroundings
We start our inspection from the outside, e.g. access roads and buildings with no fire damage, looking for forensic evidence and paying particular attention to traces that can easily be destroyed. Garages, neighbouring garbage cans, storerooms and cupboards used for cleaning materials should be checked for ignitable liquids. Can any objects of interest, such as petrol cans, bottles and matches be found close to the property? Clues as to the identity of the perpetrator are often found outdoors, for instance shoeprints or tire marks. If there are such marks, we need to rule out that they were left by firefighters, police officers etc.

We keep in mind that the purpose of the fire may have been to cover up a crime.

6.4.2 – Exterior of the building
- Which facade has been most damaged by the fire?
- What can the outer wall or roof above the windows and doors tell us? Is it covered in soot or has the soot been burnt away? (Soot can burn at high temperatures).
- Which windows have V-patterns above them and what do they tell us? Normally, the fire damage or soot pattern above a window will take the form of a 'V' spreading upwards from the window.
- Could the wind, the construction or the fire fighters have affected the signs left by the fire?
- Do the signs suggest that the fire damage has been caused by a fire inside or outside the property?
- Are there traces of soot pressed out of vents or other openings? This may indicate high pressure caused by fire starting in the room inside.

As we study the burn damages to the building, we begin formulating working-hypotheses by asking whether the fire started inside or outside. And if the fire started inside, on what floor did it start and in what room, and so on.

6.4.3 - Interior
It is important to inspect undamaged rooms as well, in order to find and collect forensic clues. Are there any signs of a fire in other places than close to the point of origin:

- How has the fire damaged the walls, ceilings, floor?
- Are there any signs of attempts to start a fire elsewhere?
- How is the fire damage to inventory?
- How has the fire spread?
- What is the fire's lowest point, and what caused this?

6.4.4 - Glass panes and openings

Soot around and outside broken glass panes, and soot around vents and other openings, can provide an indication of the fire's spread and ventilation, and can lead us to the seat of the fire.

During both rough and detailed excavations, we pay attention to where pieces of glass are found in the remains. Pieces of broken glass from windows, both those which remain in the frame and those which lie on the ground, inside and outside the building, are interesting. Has the window been broken from the inside or from the outside? For comparison we take samples.

6.5 - Fatalities

When a dead person is found at a fire site, the investigation should follow the guidelines related to homicide and suspicious deaths. It might be that the fire was created to hide traces of a crime. As long as the body and its surroundings are not completely burned or charred, it may hold evidence, and clothes or objects near the body can provide valuable information about what happened before the fire. An attempt should be made to determine the victim`s activity before and during the fire, including whether or not the person was alive. Factors that can give an indication include the location of the body (e.g. in bed, near an exit), the position of the body (e.g. in a chair, hiding), clothing (e.g. pyjamas, work clothes), burn patterns on body, clothing etc.

A human body will rarely be completely consumed by a fire, though it may be difficult to detect lesions suffered by the victim before the fire started, as skin damage caused by heat can resemble cuts and stab wounds. Lesions on bones, especially the skull, can be detected even on severely burned corpses. It is of the essence that the body or body parts are kept on site and untampered with until they have been photographed and/or video-recorded according to standard procedure. Excavation around the body requires great care, because we do not want to risk damaging body/-parts with sharp objects.

If we suspect that an ignitable liquid was used to start the fire deliberately we take samples. To best preserve such evidence, we collect the deceased person's clothes and shoes, together with material from under the body, such as bedding, cushions, carpets, flooring, car seats etc. Loose clothing can be taken directly. Clothing which cannot easily be removed has to be cut off. Either way, we only remove clothing if we are sure this will not affect the subsequent post-mortem examination. We inform the forensic pathologist about what has been changed or removed. The samples must be secured as soon as possible in fire debris bags. We make a record of any other evidence on clothes (traces of knife wounds, projectiles etc.).

When we move the body, exposed body parts such as the head, hands and feet need to be particularly well protected. If a bone or body parts is so fragile that there is a risk of it's crumbling, it should preferably be wrapped in cooking wrap until it is put into a body bag or coffin. We label the corpse, the packaging, and each of the enclosed items, in addition to photographing and making a record of them. Also see NFPA 921, Ch. 23.

6.5.1 - Cause of death

We want to establish, as soon as possible, whether death occurred as a result of or prior to the fire. This can be determined through an autopsy, the results of which may be decisive for the rest of the investigation. In any case, a forensic autopsy should always be performed of persons found dead at a fire scene.

The forensic pathologist will examine the blood for drugs, alcohol and carbon monoxide. He or she will inspect the mouth, throat and air passages for soot and burns. Examination of the lung tissues may reveal that the deceased person inhaled gases or vapours that could explain their death or give other useful information. If there is no soot in the air passages and no carbon monoxide in the blood, we assume that the person was dead before the fire started.

People who die as a result of a fire will normally have inhaled smoke, and particles of soot will be found in the air passages. They will also have inhaled carbon monoxide generated during the fire. Carbon monoxide is absorbed by blood and can be detected even after death has occurred. Even so, we still do not rule out that death was associated with a criminal act. The dead person could, for example, have been drugged, locked up, beaten unconscious etc. before the fire. Often the entire body needs to be x-rayed or scanned. Projectiles or fractures may be found, as well as traces of previous medical interventions that can contribute to identification.

6.5.2 - Identification

Identifying a badly charred body is no simple task. It often requires a dental examination and comparison with a dental journal, a DNA analysis, and/or fingerprint comparison. We look for personal physical, characteristics, and make a note of jewellery, documents, clothing and medical conditions. An important part of the process is to obtain all available *ante mortem* information about potentially missing persons. The ante mortem information will be compared to the data we have collected about the body *post mortem*.

6.6 - Delimitation of the investigation area

The point of origin (or seat) of a fire is the place or places where it started. In principle, the whole area affected by a fire must initially be considered. As the investigation proceeds, the area should shrink. The area finally determined to be the point of origin can vary in size depending on the scale of the fire damage and how difficult it is to interpret what is found in the remains.

In any fire scene investigation there will be well-defined areas of examination, and the delimitation decision needs to be based on sound reasoning, i.e. the interpretation of fire patterns and validated tactical and technical information.

It is important not to start an excavation before we have formed a clear picture of where the fire might have started.

6.7 - Excavation

In order to determine the seat of the fire, we need to excavate a delimited area, i.e. we remove fallen debris and other items to reveal what was there originally. This involves removing layers in a systematic manner. We take pains to document the process with photos and/or video-recordings.

There are various approaches to excavation. In each case, our choice of approach will be determined by the size of the fire, the weather and the degree of decomposition of the site. In general, though, we remove layers by:

- working from the known to the unknown
- working from the top to the bottom

The excavation should start from the outside and proceed towards the presumed point of origin, so that we do not overlook evidence. We also take care to examine any areas with suspicious looking fire patterns.

6.7.1 - Rough clearing

We start by roughly clearing any area that may be a point of origin, i.e. we remove large pieces of fallen fire debris (roofing, bricks, insulation, etc.). We methodically record location, orientation and level of each piece, which we save for later reconstruction and identification. We also make a note of any item that appears to be out of place. We note what materials we encounter and at what levels we encounter them. We note traces left by the fire on materials.

6.7.2 - Detailed clearing

The rough clearing of big items is followed by careful and detailed work to uncover clues about the point of origin and the cause of the fire. Suitable tools include shovels, brooms and brushes. In certain circumstances it may even be necessary to sift material. Fire residue should not be moved from the scene until the examination has been completed. An object which may seem irrelevant to begin with, may turn out to be crucial evidence.

The location, arrangement and condition of furniture, as well as what material it is made of (and other material found) can provide information about burning patterns. We want to determine what the objects are, and of course, we are particularly interested in matches, remnants of candles, wicks, tea-candle holders, lighters, fire starters, folded paper, etc. These are objects that can be used to start a fire. A perpetrator's intention might also have been to delay ignition so as to obtain an alibi.

We collect samples from areas that are likely to absorb and retain ignitable fluids: carpets, paper, furniture fabric, floor coverings and so on (*see.4.3 Sampling of ignitable liquids*). If we suspect that such liquids have been used, we pack the samples in separate fire debris bags. Visual indications of the use of ignitable fluids (reverse V-patterns, local, low and irregular burns etc.) always call for the taking of samples.

What electrical appliances and loose cables do we find? How are they located? What is the direction of the cables? Electrical items can become very fragile so we need to be careful. Are the appliances and cables connected to the grid? We study the electricity setup and the position of switches, knobs, etc. Have any fuses blown? Have circuit breakers been triggered? Do the patterns of soot and fire on the switches and knobs correspond with their state during the fire?

If we find anything that requires the on-site attention of a specialist, we discontinue that part of our examination, leaving it in-situ for the specialist. In some cases the item can be sent for further examination to an electricity expert (see 4.3.7: *Electrical systems*).

6.7.3 - Mechanical excavation and organisation of workforce

Sometimes we may want to use mechanical aids to help remove large debris. Several types of excavation machines can be used. They differ in size and function. There is also the possibility of gathering a work force (of people willing to use their muscles and shovels); the fire department, civil defence groups etc. In some cases it might be possible to get the property owner, insurance companies or other to deliver the work force.

However, certain security and safety procedures must be followed before a work force is allowed on the site, and the helpers need to be very aware of how to preserve evidence and excavate.

When mechanical excavation machines are used in combination with a work force, it is all the more important that the fire investigator has a detailed excavation strategy and that he or she closely follows the work in progress.

6.7.4 - Reconstruction for interpretation purpose

All fires leave tracks that vary depending on for instance, the duration of the fire, the presence and nature of combustibles, the layout of the structure, firefighting tactics and how the tracks have been preserved after the fire. Reconstruction of the area of origin may be necessary to locate and document those patterns and indicators that the investigator will be using to establish the area of origin.

After a small fire, particularly if it was discovered early and extinguished gently, reconstruction may not require much effort. Fires of greater magnitude tend to displace many objects and a reconstruction can seem a hopeless task. Nevertheless, since the fire itself and the firefighting may have destroyed the initial signs of the point or area of origin, the investigator's job is to "read" the fire damage, and to translate chaos into intelligible evidence.

After excavation, we try to place recovered items in their original positions. Such reconstruction may be guided by information and sketches from the owner or occupant. We also use furniture marks on the floor, clean areas on walls that have been sheltered by some object, holes in the walls from nails and screws from which pictures have fallen down, etc. Maybe we need to rebuild a staircase, reassemble disintegrated furniture, or replace wall panelling that has been torn down for firefighting purposes. When the items have been replaced, we are better able to understand fire damage patterns on the floor, the ceiling and walls, and on furniture.

6.8 - Interpreting fire patterns

As a thumb-rule, fire spreads upwards within seconds, to the sides within minutes and downwards within hours. Smouldering fire spreads slowly. Fires that occur in adjacent vertical surfaces, usually create typical V-shaped or funnel-shaped fire patterns, the “tip” of which points downward.

Hot gases normally gather just under the ceiling, and soot will be pressed out through any vents in the room (valves, open doors and windows). Such soot tracks indicates what room the fire started in. Fire damage to doorways is usually at a lower altitude in the room where the fire started. Wall coverings and ventilation conditions can have a major effect. Even if all the wall coverings have been burnt, remaining wood may indicate the direction in which the fire spread from the point of origin. We also analyse charring variations, vertically and horizontally. Even burnt furniture can indicate the direction of the spread. Soot marks that appear to contradict the majority of our findings, may be due to a change in draft conditions during the fire. Also be aware of the effect that the firefighting can have on the fire scene, such as smoke ventilation.

Damages to ceilings may indicate where the fire started The ceiling's concrete can be burned clean (no soot), and wooden ceilings may be perforated above the point of origin.

Damages to wooden floors may indicate where the fire started. Charred edges to remnants of floorboards give an indication of the direction taken by the fire. If the lower side of the floorboards are in better condition than the top, the fire will have come from above and vice versa.

Irregular burns on floors or carpets, can be consistent with the use of an ignitable liquid. Other visual clues that may indicate the use of ignitable liquids are inverted V-shaped patterns, local damage to the lower parts of a table, chair legs or skirting boards, and local damage between the tongue and groove of the floorboards.

Low-lying burn damages should always be the subject of thorough examination. They are often near the point of origin or source of ignition. Be aware that flashover and ignition of gases from ignitable liquids can lead to low-lying damages.

Window glass provides valuable information. If an explosion caused the fire, or occurred during the fire, we have to conduct outdoor examinations as well. Glass fragments from an explosion tend to be long and narrow. If we find them outdoors, we will want to ascertain which window they came from. Maybe that room was the point of origin.

If there is no soot on the inside surface of the glass, an explosion or another damage to the glass may have occurred just before or early in the fire's development. If, on the other hand, there is soot on the inside surface of the glass, the fire in the room will have lasted for some time before the window was broken. Brownish or yellowish sticky soot on the inside of the glass suggests that the fire evolved slowly. Heat damage to the glass differs from mechanical damage (i.e. damage caused by stone, tools, etc.). So we should be familiar with the guidelines for analysing glass fractures.

When we send in samples of glass to a laboratory, we make sure to include the information that the glass has been exposed to heat and include a reference if possible.

The shape of the glass in light bulbs (only incandescent bulbs) can give an indication of where the heat came from. Glass will arch towards or away from heat, depending on the size (Watt) of the bulb.

Burn marks and charring on wood indicates that the fire has gone on for some time. There are many factors to take into consideration (type of fire, intensity of the fire, geometry, ventilation conditions, wood type, firefighting etc.), it is therefore important to consider this while studying burn marks/charring.

We often see secondary damages as a consequence of a fire, so the point of origin is not necessarily where fire damage is most severe. That is why it is so important to determine what material objects are made of and where thay were located. Secondary damages can easily occur in confined areas (ventilation controlled fires) where radiant heat causes ignition of combustible materials such as curtains. Other conditions that can create misleading secondary traces are certain ventilation conditions, building layout, or areas where the fire was extinguished late. Such conditions can cause burn patterns that can be misinterpreted as a fire seat with several points of origin.They require careful attention before we can determine whether they reflect secondary damages or the primary point of origin.

More information on fire pattern is found in e.g. NFPA 921, Chapter 6.

6.8.1 - Several points of origin

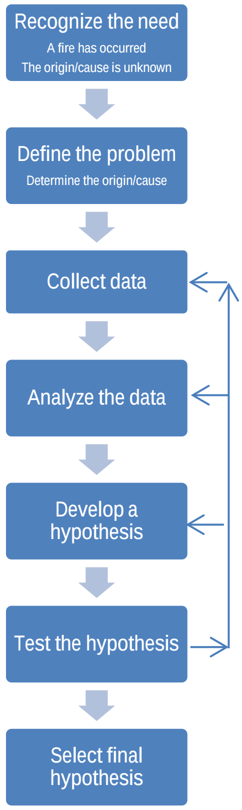
If we suspect there were several points of origin, we need to examine the fire damage as a whole: maybe the fire spread due to natural causes, e.g. along staircases, through open doors or pipes , along cables, cavities in floors or suspended ceilings. A fire can spread in four ways; by radiation, by conduction, by flow or with sparks.

Are there completely undamaged or only slightly tinted areas between focal spots? What is the distance between focal spots, and what materials are found there? The existence of unburnt inflammable materials between two focal points supports the suspicion that there are two separate points of origin. Is there any possibility of the fire's having started in several places simultaneously. If not, excavation should be undertaken in all suspected points of origin.

6.9 Analysis and hypothesis

6.9.1 - General

During an investigation we are faced with a great deal of information which must be structured and assessed according to the physical laws of fire dynamics.



The procedure recommended for fire investigation is based on scientific methodology and covers the structuring of information and the testing of hypotheses with a view to reaching the most probable conclusion.

This chapter will explain how this methodology applies to an investigation to determine the point of origin and cause of a fire. For further information, see NFPA 921.

6.9.2 – Point of origin

The scientific method requires that all collected data is analysed. This is an essential step that must take place before the formation of any hypothesis.

For origin determination, the data collection includes;

- on-scene observations (fire damages, basic site data etc.)
- information from technical systems (technical information)
- information obtained from people (tactical information)

Analysis of the data is based on the knowledge, training, experience and expertise of the investigator. Understanding the meaning of the data will enable the investigator to form hypotheses based on the evidence, rather than on speculation or subjective belief.

Fire pattern analysis is based on how a fire occurs and spread (fire dynamics) and how different fire damage patterns develop. Remember that all information should be considered, not just the pieces that "fit". It is important to include factors that may affect the fire spread, such as material properties, size and location of fuel loading, the physical dimensions of a structure, weather conditions, increased ventilation, pre-fire conditions, fire protection systems, firefighting tactics etc. Based on the data analysis, the investigator should now produce a hypothesis (or a group of hypotheses) to explain the origin and development of the fire.

6.9.3 - Cause of the fire

To determine the cause of the fire, we need to identify the ignition source, the material that was first ignited (first fuel) and the circumstances that led to the fire.

At this stage, collection of information concentrates on the point, or area, of origin. This means that we need to know where the fire started, before we can find its cause.

All possible ignition sources in and around this area must be identified. However, we should bear in mind that the ignition source may have been removed or burnt away, or maybe it is outside the point of origin (e.g. a mirror reflecting sunlight, or a stroke of lightning). In addition, we need to seek information about how relevant materials (those we have found in the area) react to fire and various forms of energy.

After collecting all the necessary information about potential ignition sources and materials in the area, and on the basis of this information (though without ruling out natural phenomena), we can envisage various scenarios for how the fire may have started. They constitute our working hypotheses. We need to keep an open mind, though, continuing to study all the hypotheses until they can be ruled out, one by one.

6.9.3 - Testing the hypothesis

Each of the alternate hypotheses that were developed must then be tested. Hypotheses can be tested physically with experiments or analytically, by applying accepted scientific principles or with references to scientific research. Experiments can be carried out in situ or in certified laboratories. When we rely on publicised research, we always have to cite our reference in the final report. The testing process needs to be continued until we are left with a single hypothesis that is deemed uniquely consistent with the facts and with the principles of science.

Any hypothesis that cannot be tested either physically or analytically, is invalid. If there is insufficient information or if alternative hypotheses cannot be eliminated, we may have to take a step back to collect more data and create new working hypotheses.

Any hypothesis formulated about the causal factors (i.e. ignition source and ignition sequence), must be based on analysed facts derived from evidence (observations, information from witnesses,calculations, physical or cognitive experiments etc.) and laws of science. Speculative information will not be included in the analysis.

Sometimes we are unable to find definitive physical evidence of the ignition source, but may still be able to give a logical explanation for how ignition could have occurred. We do so by testing all the working hypotheses with a view to finding one that is consistent with available data. Note that it is not sufficient to eliminate all but the final hypothesis; the last, remaining hypothesis must also be tested.

Testing of the hypotheses should answer the question below:
(the list of questions below are examples. Other examples will be found in e.g. NFPA921, 18.6.3)

- Is there one or several points of origin? Has the fire started in position A or position B, or in both position A and B?
- Is the potential ignition source actually capable of igniting the first of ignited fuels?
- What were the circumstances that brought the ignition source in contact with the first of the ignited fuels?

6.9.4 - Fire experiments in situ

A fire investigator has the opportunity to carry out fire experiments in situ and should have the same opportunity in a laboratory. Laboratory experiments should preferably be performed in a certified or accredited laboratory with documentation of standards.

Conducting fire experiments in situ is one way of testing a hypothesis and can help us visualise how the fire started and developed. Bear in mind that fire experiments do not provide an absolute answer, but can serve as tools to support/reject a hypothesis.

There are two main categories of fire experiments in situ:

1. Testing with a single parameter
   E.g. how will an open flame affect a specific item (i.e.material), such as a curtain.

2. Reconstructing multiple parameters
   E.g. the source of ignition and, the fabric of the curtain (including aspects such as weight per m^2, thickness etc.). Note that if the experiment is conducted outdoors, wind speed and direction should be the same as at the time of the fire.

When we design in situ experiments we bear in mind:

- The geometric layout
- How to narrow down parameters
- What method to choose
- Whether to repeat experiments
- The structure of the documentation, and quality control

6.10 - Final hypothesis - Conclusion

When the hypothesis is thoroughly consistent with evidence and research, it becomes a final hypothesis and can be authoritatively presented as the investigator's conclusion or opinion. If a final hypothesis is not considered a probability, only a possibility or a suspicion, we conclude that the cause is "undetermined".

Our goal is to find the hypothesis that is supported by most of the available data and to eliminate all alternative hypotheses. Note that not all data will necessarily fit completely. Therefore, all data must be carefully assessed: what is its value as evidence? A secure and objective forensic conclusion is consistent with available data, and contradictory data can be explained.

6.10.1 - Arson

It can be difficult, technically speaking, to determine whether a fire was due to arson. Normally there are two criteria to consider before we can conclude with arson:

1) There are several points of origin (and natural spread of fire can be excluded)

or

2) Preparations have been made to start a fire (electric timer, candles, flammable liquids, etc.)

APPENDIX 1 - WRITING THE REPORT

Writing the report is very different from country to country. The following is a recommended checklist of what to include in a report.

Introduction and basic information	Date and time Place Purpose of the investigation Conditions at the site during the investigation Investigator in charge
Working methods	Hypothesis testing
Tactical information	from people from technical systems
Fire investigation at the scene	Delimitations Description of objects Description of what is found: Outdoors Indoors Windows and other openings Fatalities, injuries List of pieces of evidence on the site and from tests
Assessment and conclusion	By hypothesis testing concluding: The point of origin The cause of fire
Definitions and references	Definitions References to validated literature Building plans/drawings

A fire report, and in particular the conclusion, should always be reviewed and approved by at least one person with fire investigation expertise, preferably one who is not involved in the investigation itself. This is especially important for large or serious cases. He or she will check all the elements of the investigation, including the use of external experts, calculations, assessments, conclusions and language (for readability). Completion of the review will be documented with signatures and date.

Such a procedure can be difficult to practice in districts where there is only one person responsible for fire investigation. The review may have to be carried out by a superior officer with relevant skills. An option is to establish forums across district boundaries, in which fire reports can be exchanged, and assessments and conclusions can be discussed. With all the IT solutions that are available, it should be easy to communicate electronically and by phone.

APPENDIX 2 - INVESTIGATION PHASES

Responding to a call → Security and safety → Preservation of context → Tactical information → Technical investigation → Determination and conclusion

First responder

Fire Investigator

Specialist

En route : – record At the site: - document • General information • Scene preservation • Communication and coordination	Secure the scene • Safety and working conditions • Security adjustment • Path of entry	Recording in situ e.g.: • 360 ° photo • Drones • Alternate light source Sampling, e.g.: • Liquids • Bottles and cans • Technical systems • Fatalities • Documents	Tactical information from: • People • Technical systems • Electronic systems	• Interpretation of information • Investigation strategy • First inspection • Delimitation • Excavation • Reconstruction	Hypothesis • Develop • Test • Conclude **Conclusion:** • **Point of origin** • **Cause of fire**

APPENDIX 3 - TACTICAL INFORMATION

	Property owner/ First person at the scene/Witness/Neighbours[1]
The property	-Are there specific hazards on the premises (for example asbestos, building components, animals)? -Ask for photographs and videos of the property, indoors and outdoors from before the fire. -Ask the occupant, or a representative, to sketch a plan of the rooms and furniture. -Was there any CCTV (surveillance camera) in the area or on neighbouring buildings? -Were the premises and/or contents insured? If so, when was the policy renewed? -Were there any electrical appliances, heating appliances or any other potential sources of ignition in the area? -Were there any fire or smoke alarms on the premises? If so, where were they located and did they operate? -Were there any ignitable materials or liquids, or materials, liable to spontaneous combustion? -What was in the area where the fire was first observed? -Who has access or keys to the property? -Who has knowledge of the code to security systems? -Are there any photographs or films of the fire, or of the property before the fire?
Actions and people before the fire	-Did any windows break before the firefighters arrived? If so, when and in what order? -Had any candles been used? -Has any repair work, alterations, welding or any type of "hot work" been undertaken in the area? If so, obtain details. -Has anyone smoked in the area of origin, and if so, when was the last time this occurred? -Have any unusual activities been noticed in the surrounding area? -Have there been any previous fires at this address? -Have there been any problems with any appliances? -Have there been any problems with the building services/fixed installations (electricity, gas and water supplies)? -If there was an intruder alarm, was it switched on prior to the fire? -Were any unusual sounds heard before the fire? -Were the doors and windows closed when people left the area? -Were there any strange smells? -What were the actions of the last person on the property? -When did that person leave the property? -When did they discover the fire? -Where were the occupants of the building when the fire broke out? What were they doing? -Where were they when they discovered the fire? What was the available lighting? -Which doors or windows were open when the fire was discovered? -Who discovered the fire? What did they see? -Had any windows broken before the fire was discovered?
Technical systems	• CCTV footage in the area • Base station checks (phone-companies) what phones were in use in the area? • Alarm logs (is the alarm connected to a remote call station? Logs from call stations might include data from individual detectors) • Access control system • Details about specific electrical devices or appliances • Details from internet (WIFI)service providers

[1]Listed questions are just examples.

	• Drawings and plans (gas pipelines, electrical grids, structural information) • Licences • Manuals about equipment • Regulations and standards • Recordings of emergency calls • Recordings of internal radio conversations (rescue service) • The amount of electricity used according to the electricity company

APPENDIX 4 - EXAMPLES OF FIRE CAUSES

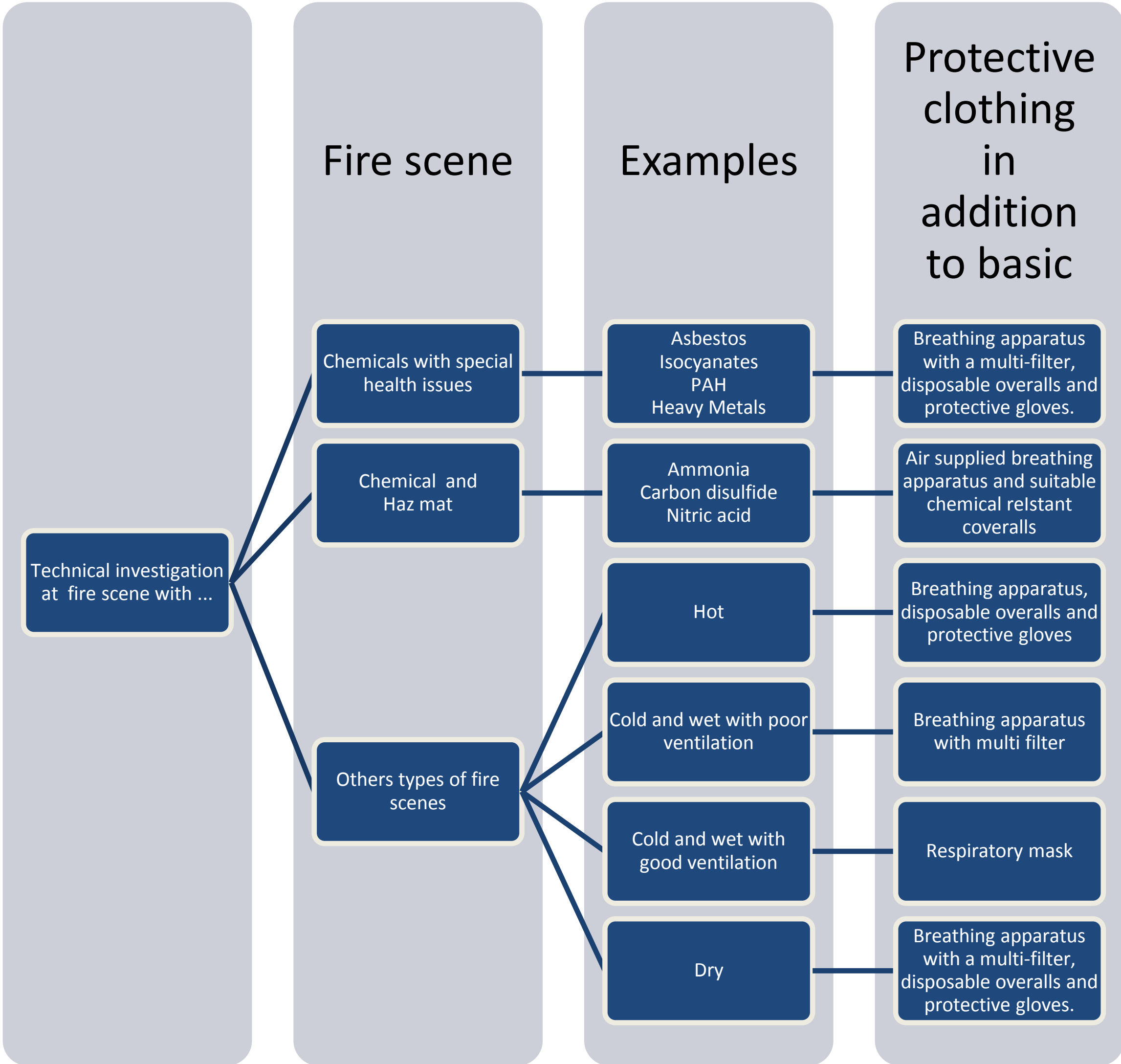
In all cases, regardless of the reason for the fire (arson, accidental, sickness, stupidity etc.), the fire image must be interpreted. Below is a short list of examples.

Auto-ignition	A substance that ignites spontaneously in normal atmosphere without an external source of ignition: -Biological (e.g. hay) -Chemical (e.g.pyrophoric substances)
Electrical	Heat conduction/convection from : -Electrical equipment and appliances (e.g. shortcuts, bad connections, overloads or insulation faults on wiring) -Lighting equipment and heaters (e.g. overheating)
Embers	Embers glow, burn and radiate heat: -Ashes (e.g. from a conventional fireplace) -Sparks (e.g. airborne embers from a bonfire) -Glowing fire debris -Live charcoal (from e.g. a BBQ) -A lit cigarette
Explosion	An explosion releases tremendous energy, usually with the generation of high temperatures: -Natural (e.g. volcanic processes) -Chemical (e.g. explosives, gases) -Electrical and magnetic (i.e. high energy electrical arc which rapidly vaporizes metal and insulation material) -Mechanical and vapour (e.g. BLEVE)
Friction	The force resisting the relative motion of solid surfaces, fluid layers and material elements sliding against each other (e.g.faulty wheel bearings or brakes).
Natural phenomenon	A natural phenomenon is an observable event which is not man-made: -Biological (e.g. fermentation of sugar into acids, gases and/or alcohol) -Chemical (e.g. fire from a rapid oxidation) -Geological (e.g. volcanic activities) -Meteorological (e.g. lightning)
Open flame	An open flame can come from e.g.: -a lighter -matches -a candle

APPENDIX 5 - PROTECTIVE CLOTHING

Personal safety equipment – basic:

- a safety helmet
- safety boots
- protective ear equipment
- protective goggles
- gloves (industrial gloves and chemical-resistant rubber gloves).
- work clothing
- disposable overalls (dust-proof overalls)
- light



APPENDIX 6 - WORK ENVIRONMENT

In a fire, a number of hazardous substances can develop, some of which we can neither see nor smell. Thanks to research, we know a lot about them. What we do not know is how long these substances remain in fire residue and for how long they are hazardous. In other words, residue at fire sites is always potentially hazardous. In addition, there is the risk of structural collapse.

Before the examination starts

- A risk analysis should be performed. This include assessing whether it is safe to enter the site.
- The risk analysis should be written by the officer in charge, who, together with his/her co-investigator, determines when it is safe to start the examination.
- The fire site is never safe before it has cooled down and been ventilated.
- For safety reasons a fire site survey should never be performed by one person alone
- Good lighting is essential.
- A dedicated ”fire-camera” should be used for taking pictures, so that hazardous matter is not carried from fire scenes to other locations.
- If it is absolutely necessary to examine a high-risk fire site, protective equipment must be used. In such cases a compressed air respirator face mask must be used. If the fire site case manager does not have access to such mask, they should be borrowed from local emergency services.

When the area is deemed safe enough to enter, an assessment must be made of what kind of protective gear will be needed. Normally, full protection requires:

- Disposable overalls with fire particle protection
- Boots with penetration protection and protective toe caps
- Approved gloves (work gloves and gloves that are resistant to chemicals)
- Fan filter respirator with mask and helmet. There are several brands of respirators with approved integrated protective helmets.
- Respiratory protection is used with a combination filter, i.e. ABEK-P.

The letters in the acronym represent air pollutants in gas or vapour form

A: Vapours and gases from organic compounds, such as solvents
B: Inorganic vapours and gases, e.g. chlorine, hydrogen cyanide, hydrogen sulphide
E: Acid gases, e.g. sulfuric dioxide
K: Ammonia and certain amines
P: Indicates the particle filter that is available in three classes, P1-P3. P3 provides protection against all types of particles, including asbestos

Decontamination of equipment

After the survey has been conducted, disposables are to be placed in plastic bags, which are sealed and then destroyed. Other equipment, including the camera, should be decontaminated with for example a soap solution (www.srsafety.com).

APPENDIX 7 - DEFINITIONS

The following list of definitions is not exhaustive. Other terms will ble found in e.g. NFPA 921.

Accelerant	The flammable material that is used in an arson to accelerate the fire process. An accelerant can be solids (i.e. paper, PUR), liquids (i.e. petrol) or gas (i.e. propane).
Arson	Fire caused by deliberate ignition, either to endanger another person's life or to destroy property. For living creatures, danger can take the form of smoke and/or the spread of fire.
Carbonisation	Residue formed in flammable material in a fire in connection with incomplete burning or pyrolysis.
Chimney effect	A rising stream of heat, smoke and gases that is confined to a shaft or similar vertical space (for example, stairways) or corners.
Combustion	A heat-releasing (exothermic) reaction between flammable materials and an oxidant (air, oxygen), usually followed by smoke, flames or embers.
Combustion temperature	The temperature the flammable material reaches when it burns.
Complete combustion	All organic material is burnt away and consumed in the combustion process.
Concentrated destruction	Description of demarcated area sustaining fire damage following the ignition of flammable material in solid form or following ignition with ignitable liquid. The extent of the fire damage depends on the properties and construction of the material. When igniting an ignitable flammable liquid, the underlay can act as a wick for the remaining liquid in the course of the fire, which is why the fire can continue in the material.
Condensation	What happens when a substance goes from the gaseous phase to the liquid phase.
Conduction	Transfer (of heat, for example) by means of conductivity through solid materials. Metals are good heat conductors.
Convection	Transfer (of heat, for example) by means of a current (for example, a hot air flow from a wood-burning stove or hot flue gases).
Deflagration	A chemical reaction (rapid combustion) that can vary from a few metres a second to several hundred metres a second, depending on the chemical composition of the fuel: For example, 1-10 metres a second for petrol vapour to several hundred metres a second for black powder or nitrocellulose. Deflagration occurs where the speed of combustion is lower than the speed of sound, as opposed to detonation. Thus, an exhaust gas explosion or dust explosion is a deflagration.
Density	The mass of a material in relation to its volume (expressed in kg/m^3). Also called specific gravity or mass density.
Detonation	A chemical reaction of explosive materials that spreads at supersonic speed (thousands of metres a second) and releases large volumes of energy and high temperatures. Thus, an explosion in an exploding substance (explosive) is a detonation.

Endothermic	A combustion process that cannot continue without the addition of heat.
Exothermic	A combustion process that releases heat and continues by itself without depending on an external heat source. (See also Endothermic).
Explosion	An explosion is a rapid expansion of gases caused by either a combustion or by the release of excess pressure. Can also be described as the sudden formation of (potential) energy for motive power with the production and release of gases under pressure, or the release of gas under pressure. This release of high pressure gases can move, alter or destroy nearby materials. The energy content in explosions is measured in TNT. 1 ton of TNT is equivalent to an energy content of 4,184 gigajoules.
Explosive ranges	See "Flammability limit".
Fire	An uncontrolled combustion process during which heat, smoke, flames or embers are emitted.
Fire load	The total heat output that can potentially be released during the complete combustion of all flammable material in a room or an area. Measured in joules. (The volume of the flammable material present that can potentially catch fire).
Fire machine	A construction designed for igniting a fire using a time-delay device. A fire machine can be constructed in many different ways, and examples of fire machines include electronic/mechanical (with an on/off timer), chemical (acid) or simply a naked flame placed on flammable material.
Fire resistance	A construction's ability to withstand the effects of fire expressed in connection with standardised testing. Expressed in minutes.
Flame	A luminous combustion zone that results from the reaction between gases and which creates heat.
Flaming fire	A combustion process that arises in flammable material when it is in its gaseous state and is at a sufficiently high temperature.
Flammability limit	The lower and upper flammability limits indicate the range, expressed as a volume percentage, in which a mixture of the substance (gas, liquid vapour or dust) and atmospheric air at a normal temperature can be ignited. The range between the two limits is also referred to as the flammable range or the explosive range.
Flashover	The moment when all flammable material in the room is involved in the fire. All flammable material in the room has reached ignition temperature and the fire is fully developed.
Flashpoint	The lowest temperature at which a flammable/ ignitable liquid releases combustible vapours.
Melting point	The temperature at which a material goes from solid form to the liquid/fluid phase. (Expressed in degrees C).
Heat conduction	Heat that flows through a solid material.
Ignition source	The source of heat or flame that is used to ignite a material.
Ignition temperature	The temperature to which a material has to be heated using a standard method in order for it to burst into flame in atmospheric air.

Incomplete combustion	A combustion process in which not all flammable materials are burnt completely (CO and soot is formed).
Non-flammable material	A material that cannot be ignited/burn under established testing conditions. (ISO 1182).
Optimal mixture	The proportion of each component in a mixture of flammable gas and air which gives the quickest and cleanest combustion.
Oxygen	An element, odourless, invisible, non-flammable but fuels a fire. (O_2 – ordinary air contains approximately 21% O_2).
Picture of the fire	A comprehensive observation of the site of the fire.
Point of Origin or Initial Fire	The place at which the fire started.
Pyrolysis	Chemical fission of a material due to the influence of heat
Radiation	The transfer of heat in the form of electromagnetic waves (infrared light, transmitted in straight lines at the speed of light).
Smoke	Small solid particles in gas, caused by combustion or pyrolysis.
Smoke and heat ventilation system	A system that is used to direct and remove smoke, heat, odours, flames or flue gasses in a building during a fire.
Smoke ventilation system	Ventilation for removing smoke, gases etc. in the event of a fire.
Smouldering fire	A fire in flammable material without the presence of flames but with the generation of light and heat (and possibly smoke) from the combustion zone (the speed of combustion is below 1 mm a second).
Spontaneous ignition (combustion)	Self-heating of flammable material resulting in ignition. The causes of spontaneous ignition can be divided into three processes: 1: Chemical reactions/spontaneous ignitions 2: Physical causes 3: Biological causes.
Sublimation	Distillation at low temperature. A material that goes directly from solid form to gas/vapour form (for example, wood and paper etc.).
Under ventilation	Development of a fire where the supply of air is less than what the fire needs.
Vapour	The gaseous state of a substance which, under normal pressure and temperature conditions, is usually a liquid.

REFERENCES

- NFPA 921, Guide for Fire and Explosion Investigations
- Practical guide for fire investigators and specialists in fire and explosion investigations, ENFSI

- Kirk's Fire Investigation, John D. DeHaan/David J. Icove, Pearson
- Practical Fire and Arson Investigation, John J. O'Connor, Elsevier
- Scientific protocols for fire investigation, John. J. Lentini, CRC Press
- Enclosure fire dynamics, Björn Karlsson/James G. Quintiere, CRC Press
- Elektricitet och brander, David Widlund, MSB
- Ignition handbook, Vytenis Babrauskas phd., FSP/SFPE
- Brannfysikk – fra teori til praksis, Guttorm Liebe, Norsk brannvernforening
- Håndbok i brannetterforskning, Norsk brannvernforening
- Crime scene management and evidence recovery, Deborah Beaufort-Moore, Oxford

WORK ENVIRONMENT

For more detailed research on the topic so cited, including following reports and checklists issued in the Nordic countries:

- HMS håndbok for politi- og lensmannsetaten, Politidirektoratet
- ”Arbetsmiljöproblem vid brandorsaksundersökning” (Christer Pedersén, Specialarbete kriminalteknisk grundutbildning 2003-2004, Sverige).
- ”Asbestfaran på brandplatser” (Helene Almgren, Specialarbete i kriminalteknisk grundutbildning 2007-2008, Sverige).
- ”Rutin för arbetsmiljöarbete vid brandplatsundersökningar” (Polismyndigheten i Dalarna, Sverige).
- ”Arbetsmiljöarbete vid brandplatsundersökningar” Polismyndigheten i Örebro län, Sverige).
- ”Foranstaltninger mod farlige kemiske stoffer på brandsteder”. (Crecea rapport. Rikspolitiet, Efterforskningsafdelningen, Kriminaltekniskt center, Danmark).
- ”Sikkerhedsvurdering av Brandsted” samt ”Brug af personlige værnemidler” (Rikspolitiet, Efterforskningsafdelningen, Kriminaltekniskt center, Danmark)
- ”Instruks – For arbeide på steder hvor det er fare for påvirkning av asbest eller helseskadlige branngaser” samt ”Instruks – HMS på åsteder” (Oslo Politidistrikt).
- ”Kemikaalialtistumisen vähentäminen palokohteissa” – ”Skyddsanvisning för brandutredare” (VTT Technical Research Centre of Finland - Finland)

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