



Best Practice Manual for the Investigation of Fires and Explosions

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ENFSI

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Best Practice Manual for the investigation of fire scenes

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Owner of the BPM is the Fire and Explosion Investigating Working Group.

Responsible for revision 2021 and of original document:

Eva Ljungkvist, NKC Danish National Police eb1006@politi.dk

1 AIMS

The aims of the manual are to provide a framework for procedures, quality principles, and training processes and approaches for the examination of fire scenes. This BPM can be used by member laboratories of ENFSI and other forensic science laboratories to establish and maintain working practices in the field of forensic examination of fire scenes that will deliver reliable results, maximize the quality of the information obtained and produce robust evidence. The use of consistent methodology and the production of more comparable results will facilitate interchange of data between laboratories.

The term BPM is used to reflect the scientifically accepted best practices at the time of creating. The term BPM does not imply that the practices laid out in this manual are the only good practices used in the forensic field. In this series of ENFSI Practice Manuals the term BPM has been maintained for reasons of continuity and recognition.

2 SCOPE

This BPM is an overarching document relating to the investigation of fire scenes, which is underpinned by a set of subject specific appendices.

This BPM is aimed at experts in the field and assumes prior knowledge in the discipline. It is not a standard operating procedure. The BPM addresses the requirements of judicial systems in general terms only. This document does not address laboratory examination of items, individual competence of practitioners (including training requirements), specific jurisdictional requirements, or country specific legal requirements.

3 DEFINITIONS AND TERMS

For the purposes of this Best Practice Manual (BPM), the relevant terms and definitions given in ENFSI documents, the ILAC G19 “Modules in Forensic Science Process”, and in standards such as ISO 9000, ISO 17000 and 17020 apply. Other relevant and specific definitions are presented in each of the appendices. There shall be a bi-annual review of the BPM. The steering committee of the FEIWG is responsible for the review.

4 RESOURCES

Management of the resources required for a fire scene investigation must take into consideration the appropriate and applicable areas of quality standards. It must also be recognised that many aspects of fire scene investigation will not be specifically addressed in such standards.

4.1 Personnel

Fire scene investigators have a wide range of experience, training and background knowledge which can be obtained through a variety of routes (academic, continuous professional development, vocational training, operational experience etc.). Fire scenes are defined as scenes involving fire damage and/or scenes involving gas phase explosions.

The classifications of fire investigators have been defined in general terms and are presented in Appendices A1 and A2.

4.1.1 Competence requirements

Fire scene investigators must be competent and trained to their relevant national standards. Table 1 indicates knowledge and skills recommended for fire scene investigators.

Table 1: Knowledge and skill set

1. Understanding the importance and relevance of health and safety at scenes and that this may vary depending on the scene.
2. Understanding the importance of a structured, systematic methodological approach to fire scene investigation and excavation including the recording (e.g. written, photographic, video) of the scene investigation.
3. Awareness of aspects of fire science and fire engineering which may have a relevance to fire investigation (e.g. fire dynamics, structural performance, passive and active fire protection systems, fire tests, and human behaviour in fire).
4. Understanding the mechanisms of heat transfer.
5. Understanding the differing types and mechanisms of ignition.
6. Understanding the physical and chemical properties of solid, liquid and gaseous fuels and materials as they relate to their thermal decomposition including pyrolysis and combustion and how such fuels and materials will react when exposed to heat and to firefighting activities.
7. Understanding the mechanisms and influencing factors of fire growth and development in a wide range of circumstances.
8. Understanding the interpretation of post fire indicators (including their limitations) and the use of such indicators in the determination of the area(s) of origin of a fire.
9. Understanding the potential involvement of electricity as a cause of fire and awareness of the post fire indicators of electrical involvement.
10. Awareness of the importance of the examination of fuses and electrical appliances and the appropriate means of securing electrical appliances post fire.
11. Awareness of diffuse phase explosions and gas explosions including the pattern of damage.
12. Understanding the factors, which may contribute to fire fatalities including aspects such as toxicity of products of pyrolysis and combustion.
13. Understanding the procedures relating to the recovery of items (including human fatalities) from fire scenes including the importance of continuity and integrity of evidence and chain of custody.
14. Understanding the requirements for contamination control, appropriate packaging materials and the importance of control and comparison samples in the collection of fire debris suspected to contain ignitable liquids.
15. Understanding of the general characteristics that suggest the production of either chemical substances or homemade explosives (Appendix C1 and C2).
16. Understanding of the fire investigators role and responsibilities in relation to interviewing witnesses taking into consideration national legal requirements.
17. Understanding that fire scene investigation is a destructive examination process that makes the original observations impossible for re-examination.
18. Keep accurate and original records of casework. Prepare reports and/or statements appropriate for the national criminal justice systems. Give testimony and communicate their involvement in the case, their findings and conclusions, in a transparent, traceable and appropriate manner within their field of expertise.
19. Understanding of the local working practices in relation to multi agency responses to fire and explosion scene investigation.
20. Awareness of the wider specialisms as they relate to fire scene investigation (e.g. forensic chemist, forensic biologist, forensic anthropologist, technical specialists including electrical specialists, engineers etc.) and the requirements of such specialists within the investigative framework.
21. Understanding the requirements of local criminal justice systems and in particular the rules of evidence and the obligations of being a witness with fire investigation expertise for the courts.

4.2 Equipment

A variety of equipment is used during a fire scene investigation some of which is detailed in the appendices to this BPM (Appendix A1 and A2). When using equipment in fire scene investigation consideration should be given to the following points:

Equipment should be calibrated and maintained according to the operating manuals and periodic calibration and calibration checks must be recorded in a log book associated with the piece of equipment. All tools and non-disposable personal protective equipment and clothing must be cleaned and free from contaminants or replaced between use at different scene locations or situations where potential cross contamination would be an issue.

Equipment and tools must be regularly inspected and replaced if damaged to an extent that cleaning procedures are ineffective. Cleaned utensils and tools should be sampled prior to use and the samples retained for further testing if required. Equipment must be stored in such a way as to ensure minimal risk of biological or chemical contamination prior to use.

Cleaning and sampling records of non-disposable equipment must be kept where reasonably practicable. Where contamination may have occurred, this must be documented in the examiner's scene notes.

4.3 Reference materials

Not Applicable

4.4 Facilities and environmental conditions

Not Applicable

4.5 Materials and Reagents

In circumstances where the fire scene investigator is competent to carry out presumptive testing, then only validated materials and reagents (for example for the presumptive testing for blood, or the swabbing of suspected blood) may be used.

5 METHODS

A comprehensive methodology for the investigation of fire scenes is presented in Appendices A1 and A2. Further appendices present the methodology for the investigation of specific types of fire scenes.

6 VALIDATION AND ESTIMATION OF UNCERTAINTY OF MEASUREMENT

6.1 Validation

The validation of the fire scene investigation process is heavily dependent on the (1) investigating organisation, (2) the skills and competency of its staff and (3) the techniques and equipment used. The investigating organisation must provide the appropriate resources to facilitate the fire investigation process to be undertaken. The fire scene investigator must be appropriately qualified and competent. Their training must be documented, assessed and they must undertake both continuous professional development and maintain and demonstrate their skills and competency.

- The equipment used in fire scene investigation must be validated by testing repeatability, reproducibility, selectivity, sensitivity and robustness (including robustness at the scene using control samples where appropriate) either through reference to the professional literature or manufacturers specifications or by in- house methods.
- The investigative techniques (for example the recognition and interpreting of burn patterns) used in fire scene investigation can be validated using known ground truth data, literature and testing.

- Implementation-based validation studies can demonstrate that the method, validated by other parties, is mastered by the team or the researcher and that the adapted method produces reliable results.

6.2 Estimation of uncertainty of measurement

The fire investigation process is dependent on the knowledge and skill set of the fire investigator as detailed in Section 4.1.

The identification and specification of the main sources of uncertainty relating to the decision making and hypothesis testing associated must be stated. The determination of origin, cause and, if required, subsequent fire development in a fire scene investigation must be recorded in the investigators documentation and presented in the final report.

Uncertainties in the entire fire scene investigation process arise from a number of sources which include (but may not be limited to):

- Competence of the investigator and their specific expertise and experience.
- The amount and quality of information received.
- Assumptions made during the investigation process.
- Specific environmental conditions.
- Destruction of evidence due to the fire.
- Firefighting activities.

6.3 Peer Review

Review of reports is mandatory in some jurisdictions. It is strongly recommended that reports be critically reviewed to check that the presentation of the report is fit for purpose and to ensure that the information available at the time of the investigation and derived from the scene investigation has been interpreted appropriately. Such reviews must be recorded. It is advantageous if the review process begins with a discussion of possible fire cause propositions on the basis of photos before the report is done.

7 QUALITY ASSURANCE

There are no proficiency tests currently available for fire scene investigation. Fire investigators are advised that they should take part in a relevant collaborative exercise/test for fire scene examination periodically so that their competence can be demonstrated and assessed.

This can be an internal or an external test. See for more information for example QCC-PT-001 "Guidance on the conduct of proficiency tests and collaborative exercises within ENFSI". This guideline provides information for the ENFSI Expert Working Groups (EWGs) on how to organise effective proficiency tests (PTs) and collaborative exercises (CEs) for their members.

8 HANDLING ITEMS

8.1 At the scene

Appendices A1 and A2 provide a comprehensive methodology for the recovery of items from fire scenes including the avoidance of contamination. Further appendices provide additional information relating to specific types of fire scenes.

8.2 Sampling, preservation, packaging, labelling and documentation.

Appendices A1 and A2 provide a comprehensive methodology for the recovery and traceability of items from fire scenes including the avoidance of contamination. Further appendices provide additional information relating to specific types of fire scenes.

8.3 Transportation

The transfer of recovered items must be carried out according to local operating procedures and legislated responsibilities used by the investigating authority or the fire investigator.

During this process the fire investigator must ensure that they witness the handover of recovered items to another person or organisation and ensure that there is a written record within their notes or items list. Items must be transported and stored in a manner which prevents contamination, degradation or damage while maintaining the security and integrity of the exhibits.

8.4 In the Laboratory

Not applicable

9 INITIAL ASSESSMENT

Within a given case, an initial scene assessment strategy must be established with all investigators involved in the process. This must be based on the information provided to them at the time and continually reviewed in light of new circumstances and information. The scene investigation strategy must also take into account other information and evidence relevant to the specific case. This is expanded upon within the appendices.

10 PRIORITISATION AND SEQUENCE OF EXAMINATIONS

Prioritisation and the sequence of scene investigation must normally be agreed between the fire investigator and investigating authority and in accordance with local agreements (for example a memorandum of understanding or other formal agreement between agencies). Prioritisation and the sequence of scene investigation must be documented so that decisions are recorded and reviewed and must involve an assessment of (but is not limited to) the following:

- Initial information received.
- Initial observations of the external/internal examination of the scene.
- Potential value of the examination and/or recovery of specific items within a scene to the overall investigation.
- Order of requirements of other specialists if they are required (for example, forensic chemist, forensic biologist, forensic pathologist, forensic anthropologist, technical specialists including electrical specialists, engineers etc.)
- Time constraints (which may lead to loss of potential evidential materials such as volatile compounds).
- Health and safety implications.
- Environmental conditions.

This is expanded upon within the appendices.

11 RECONSTRUCTION OF EVENTS

Carrying out a forensic reconstruction is a methodology which can deliver additional value to already known investigating results of examined traces (evidence) in forensic investigations and/or can give insight on how traces are donated or created (activity orientated).

The preceding sentence can be interpreted broadly and depends on the nature of the forensic investigation carried out. By means of a reconstruction, for example, the degree of probability of how and where an activity occurred can be strengthened or weakened. The results of a reconstruction can therefore influence the interpretation and the strength (value) of conclusions obtained from evidence.

The kind of the reconstruction can give direction about the necessary level of details and amount of information one could record. Subjects for registrations could be: the involved investigators, the detailed set-up of the reconstruction, technical aspects, registration of all matters which may have influence on the results, registration of the reconstruction (photograph's, video) etc. The well documented reconstruction allows, if needed, a professional review afterwards.

Reconstruction of events can be particularly relevant in fire scene investigation and can be undertaken in a number of different ways. The assumptions and limitations of reconstructions should be noted.

Physical reconstruction is a process where items are replaced (as far as possible) in their original positions prior to the fire. This can assist in the fire investigator's interpretation of the area of origin, cause and subsequent fire development.

Ad-hoc testing (e.g. a test burn for flammability of a material) can be carried out either at the scene or at a later stage in the investigation and must be fully recorded including any assumptions made and the value and limitations of the test.

Use of *computer modelling* must be approached with caution and all assumptions, limitations and uncertainties associated with the models clearly recorded.

Full scale fire reconstructions can be carried out in controlled conditions after the initial fire scene investigation and must use validated equipment e.g. thermocouples and other monitoring devices.

Further information is available in appendix A2.

12 EVALUATION AND INTERPRETATION

A range of hypotheses must be considered during the evaluation and interpretation of all of the information received and gathered relating to a specific scene investigation process. This is expanded upon within the appendices.

At least two causes of fire must be evaluated as competing propositions (hypothesis). Each proposition must be explored systematically using the information and physical evidence that is interpreted and evaluated by the fire investigators and an overall opinion formed of the most likely origin and cause of the fire. In some jurisdictions (but not all) this may be expressed as a likelihood ratio. Further information is available in the ENFSI *Guideline for Evaluative Reporting in Forensic Science*.

13 PRESENTATION OF RESULTS

The overriding duty of those providing expert testimony is to the court and other legal enquiries. As such, evidence should be provided with honesty, integrity, objectivity and impartiality. Evidence can be provided to the court either orally or in writing.

The manner in which evidence is presented will differ depending on different legal jurisdictions. Fire investigators must comply with their legal obligations and accreditation requirements within the jurisdiction in which they are collecting and presenting their evidence. Presentation of evidence should clearly state the results of any evaluation and interpretation of the examination.

Written reports should include all the relevant information in a clear, concise, structured and unambiguous manner as required by the relevant legal process. A checklist of the information suggested is expanded upon within the appendices.

Written reports must be peer reviewed where this is a jurisdictional requirement. Reports should clearly state the results of any evaluation and interpretation of the examination.

All viable hypotheses must be evaluated and conclusions supported by an up to date understanding of accepted methodologies and literature.

Recommendations associated with the production of written reports are expanded upon within the appendices.

14 HEALTH AND SAFETY

Health and safety, risk assessments and personal protective equipment are expanded upon within the appendices. In addition;

- The relevant national Health and Safety Legislation must be complied with.
- Specialist equipment operated at the fire scene must be used by those trained to do so.
- Where fire scenes contain specific risks to health and safety, for example chemical or biological hazards, special precautions and personal protection equipment (PPE) are required and are detailed in the relevant appendices.
- Counselling should be available to investigators.

15 REFERENCES

Bibliography can be found in Appendix A0.

16 AMENDMENTS AGAINST PREVIOUS VERSION

The first part of the BPM has been adjusted to comply with the approved template.

Appendix A1 has been updated.

Deletion of separate reference codes and document type identification of appendices A1 and A2.

A new appendix has been added – Appendix A3 Explosion investigations.

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APPENDIX A – BIBLIOGRAPHY

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SWGDRUG: Scientific Working Group for The Analysis of Seized Drug (SWGDRUG) Recommendations.

The recommendations include: Code of Professional Practice, Education and Training, Methods of Analysis and Quality assurance,
<http://www.swgdrug.org/Documents/SWGDRUG%20Recommendations%20Version%207-0.pdf>

ILAC G19:08/2014, International Laboratory Accreditation Cooperation, <http://ilac.org/news/ilac-g19082014-published/>

APPENDIX A1 – FIRE INVESTIGATIONS FOR FIRST RESPONDER

This guide is the result of a unique collaboration and would not have been possible without participation from the following institutes and guest members.

Bundeskriminalamt	Austria
Institute of Criminology	Czech Republic
National Center of Forensic Services	Denmark
Danish Institute of Fire and Security Technology	Denmark
National Bureau of Investigation	Finland
Institut de Recherche Criminelle de la Gendarmerie Nationale	France
Netherlands Forensic Institute	Netherland
Bayerisches Landeskriminalamt	Germany
Police	Israel
Fire and Rescue Research centre	Lithuania
Forensic Science	Northern Ireland
National Criminal Investigation Services	Norway
National Forensic Laboratory	Slovenia
Portuguese Forensic Laboratory	Portugal
National Forensic Center	Serbia
Catalonian Police	Spain
National Forensic Center	Sweden
Ecole des Sciences Criminelles, Lausanne	Switzerland
Police Cantonale Neuchateloise, Service d'identification judiciaire	Switzerland
Forensic Science Service	UK
CAHID, University of Dundee	UK
Scottish Police Authority Forensic Services	UK
Key Forensic Services Limited	UK

If you have any comments, additions, suggestions or remarks you can contact the authors at wg-training@unil.ch. You can find the latest version of this guide on the ENFSI website (www.enfsi.eu). We would like to thank Stuart Ritchie, CC Forensic P/L Australia for review.

Fire and Explosion Investigation Working Group - Fire Scene Investigation

Persons responsible for this revision:

Eva Ljungkvist eb1006@politi.dk

Benny Thomsen bth005@politi.dk

Both from Danish National Police, National Forensic Services

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1 AIMS

This practical guide aims to provide a framework for First responders, both from the public and private sectors. It offers recommendations for how to conduct an investigation at the scene of a fire, in order to achieve the best possible results. A First responder investigating a fire scene is someone who is involved in determining the origin, cause and development of a fire and/or explosion. This work brings together current available knowledge and material and is the result of an extensive study of current practice used by forensic science laboratories and institutes throughout Europe.

The term 'practical guide' does not imply that the practices laid out in this manual are the only acceptable methods used in fire scene investigation.

2 SCOPE

This document is relevant to all First responders attending a fire scene in order to ensure that specific initial information is not lost. This document acts as a guide, and defines the purpose of the process, and the series of steps that must be followed from the time a First Responder is notified of involvement at a fire scene, until the presentation of findings, whether by report alone, or through the provision of evidence in the court room. Personnel involved in the investigation of fires are divided into three levels, and can all be involved in determining the origin, cause and development of a fire and/or explosion:

First responder Fire and explosion investigator Specialist

The boundaries between each of the different levels are not clearly defined. A fire investigation, which initially seems simple, can turn out to be very complicated and may need to be dealt with by a specialist.

3 DEFINITIONS AND TERMS

General definitions related to quality, involvement and different phases of the investigation are given in *Appendix A2 -appendix A- Investigation phases*. There is no requirement to repeat these within the guideline. Keywords with definitions¹ important for First Responder are listed below:

Competence is the demonstrated ability to apply knowledge and skills and, where relevant, demonstrated personal attributes.

Contamination is the undesirable introduction of substances or trace materials to exhibits/productions at any point within the forensic process.

Critical Findings Observations and results that may have significant impact on the conclusion reached and the interpretation and opinion provided.

Validation is the confirmation by examination, and the provision of objective evidence that the particular requirements for a specific use are fulfilled.

4 RESOURCES

4.1 Personnel

The First responder must verify that they have demonstrable competencies and experience that are relevant to the task at hand. A conclusion will qualify as scientific findings if it can be demonstrated that it is the product of a sound scientific method. The 'scientific method' is the process of formulating hypotheses, and then conducting experiments/analyses to provide support for, or against, the hypothesis that is considered relevant at the time. This may lead to the formulation of further hypotheses, as the process is repeated. The First

¹ ILAC G19-8/2014

responder is qualified by knowledge, skill, experience, training and education and may give evidence in the form of an opinion, or otherwise if:

- The expert's scientific, technical, or other specialized knowledge will help the court to understand the evidence or to determine a disputed fact.
- Their testimony is based on sufficient facts or data.
- Their testimony is the product of reliable principles and methods.
- The expert has reliably applied the principles and methods to the facts of the case.

4.2 Equipment

See Appendix A2 -section 5 – Methods.

4.3 Reference Materials

See Appendix A2 -section 15 - References.

4.4 Facilities and Environmental Conditions

See Appendix A2 -section 5 - Methods and section 14 - Health and Safety.

4.5 Materials and Reagents

Not applicable.

4.6 Allocation of Responsibilities and collegiate approach

See Appendix A2 section 4 – Resources

5 **METHODS**

5.1 Basic principles – action card

The action card is designed for the First Responder, but the contents can also be used by other experts in order to determine the necessary disposition (of personnel/resources etc.), to assess how the investigation will proceed. It is important for a well-functioning, structured investigation, to obtain the tactical information from persons involved, the Fire Department, and from witnesses. In addition to this, is the information available from any injured persons (including fatalities).

The First Responder completes a report that describes the fire investigation in an accurate manner, and in doing so will provide an initial overall picture of the scene/event. In some situations, there may be a requirement to initiate an urgent collection of evidence, and a preservation of the fire scene. The First Responder can cooperate with the officer in command from the Fire Department and other authorities. The assessment of the case can be done in conjunction with the police officer in charge, with the view to the progress and strategy concerning the fire investigation.

This also takes into consideration the expertise and knowledge required for further fire investigation. In simple and uncomplicated cases, the First Responder may complete the fire investigation directly, after the Fire Department has finished their incident response. The action card should be seen as a guide and a support in relation to the interface between tactical and technical investigation. It can also be used by the individual investigator to assess his/her own abilities and skills for the task at hand, and when a request for assistance is required. The First Responder is the investigating person where the fire scene is simple, and the fire damage is limited. It is a recommendation that the First Responder request for assistance of a Fire Investigator and/ or a specialist, in cases listed as below:

- Fatalities due to fire
- The fire scene is complex or severe, or complex damages at the fire scene require the need for comprehensive clearing
- Requirement for tactical information from technical systems or reconstruction / fire experiments in situ
- A demanding work situation, or a suspected arson

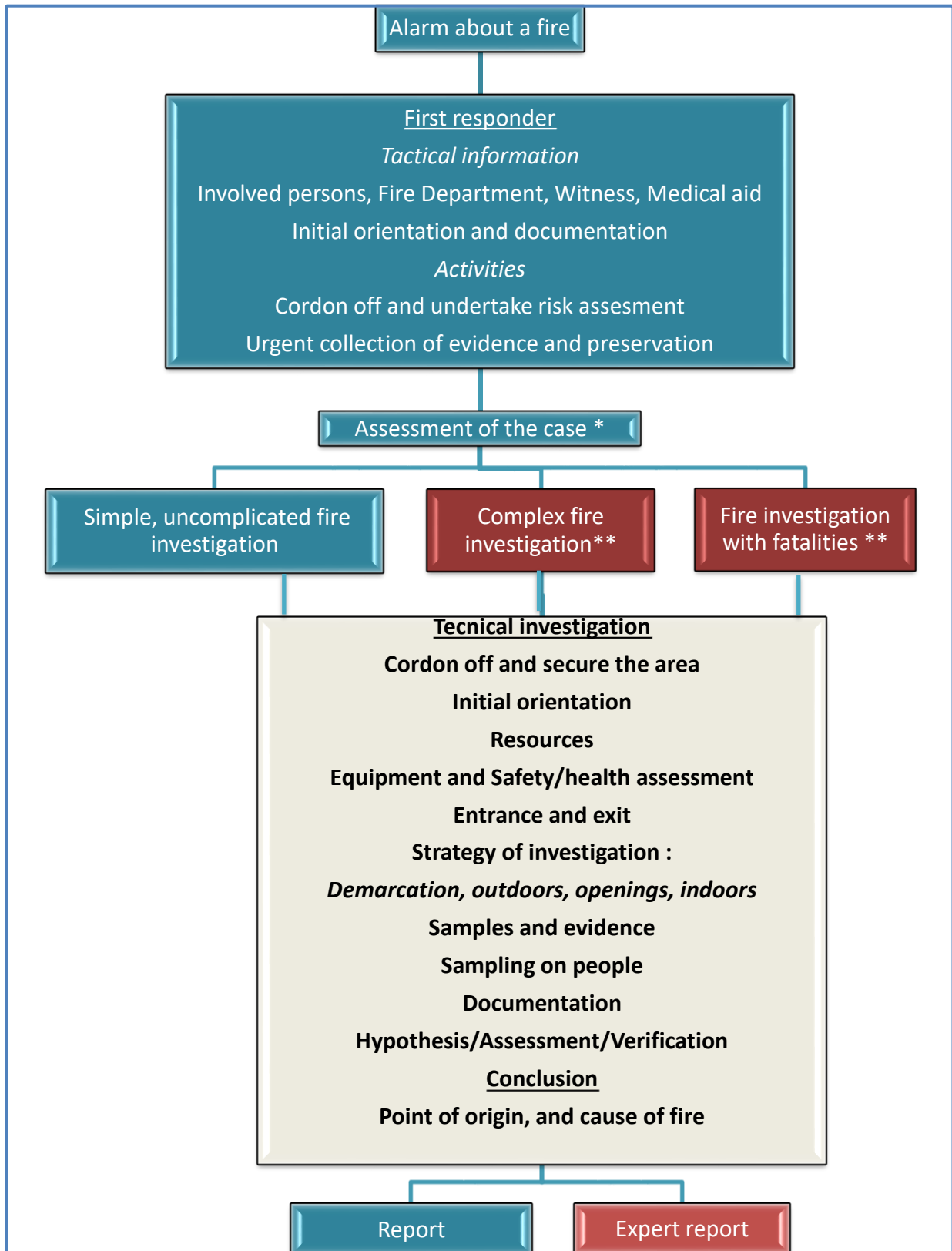


Figure 1 Action card Fire investigations

* The assessment of the case is typically based on the tactical information received.

** For example, heavy fire damage, complex building structure, need for reconstruction /clearing, difficult working conditions, technical systems.

5.1.1 Responding to a call or request for assistance

The First Responder is likely to be the first to collect the relevant information needed for an investigation strategy, and could also be responsible for both the collection of evidence, and that the operating procedures are followed. If a fire investigator or a specialist is responding, priority is to preserve the fire scene as undisturbed as possible.

5.1.2 On route and on arrival

Wherever possible, the following shall be recorded:

- The time of the call, and all current available information.
- People's present (witnesses, other attendants, journalists, others), and details of vehicles.
- Deviant or specific activities of people's present.
- Identify details of bystanders, especially if they appear to be particularly interested, or if someone present displays unusual behaviour.
- People present at the fire scene should be considered for examination concerning clothing, behaviour, intoxication and response to the incident, and the relevant findings, including fire damaged hair, soot, singed hair on hands and on their face/extremities.
- If possible, anyone who has left the scene.
- Weather conditions: (general wind speed and direction, as well as any changes in the weather).
- Security assessment, evacuation / rescue of persons and extinguishing efforts.
- The consequences of the Fire Departments incident response.
- Confirm pictures and videos are documented, dated and retained.

On arrival, there should be a reflection on using dogs for tracking traces on the scene and access/escape routes. Depending on the tactical information given, it could be a dog specialized on search or on ignitable liquid etc.

5.1.3 On-site

The First Responder should as soon as possible, determine whether or not to contact a Fire Investigator / Specialist.

Take photos and notes, as well as start plotting (with their own observations), as soon as possible, to fully document the fire scene. Photographs and notes must include all angles and aspects of the fire scene, including any areas that were unburned at the time of arrival.

Take a sequence of photographs of the fire spread, paying particular attention to the location of smoke and flames when you arrive. If possible, take a comprehensive photo shoot around the building.

It is also recommended to record the fire scene using, for example, video, drones, 3D scanning, 360°. Make sure photos and videos are dated, and show the correct time.

Note the fire-fighter's first immediate comment – (in their own words, verbatim if possible). The recommendation is to interview the personnel from the Fire Services as soon as possible. One can also get valuable information from witnesses, technical systems, and the owner of the property at an early stage.

5.1.4 Cordon off, and preservation of the fire scene

It may be necessary to make an immediately sampling, or urgent preservation of the scene. This can happen during the Fire Departments response, or in connection with the cordoning off of the scene before leaving.

To ensure the integrity of the site, it may be necessary to close the area off. Make sure that as few people as possible have access to the investigation area. Consider using an inner area, and an outer area, if it works best. Make sure that the outer barrier is sufficiently large to cover all areas that contain possible traces and evidence.

To ensure the preservation of the fire scene, it is often necessary to lock up the fire scene. That can be for example, a closing of any open windows or doors, with wooden plates, and cover roof openings. These measures will, in addition to protection from the weather, have a certain effect to keep the public away, but they should not stop, or prevent, access to the site.

Immediate collection of specimens and sampling can be the protection of blood on a broken pane, or the lid of a petrol tank, a bottle, tool, clothing, a lighter, etc., found in connection with the scene of the crime, and suspected of being caused by a perpetrator, or otherwise relevant to the case. Electronic evidence can be of great importance, such as Wi-Fi readout.

Urgent collection of evidence can also be that you are required to cover over a shoeprint. Urgent preservation of the fire scene is made to protect any tracks/trails etc., identified during extinguishing efforts, to protect them against wind and weather, as well as to ensure the evidentiary value of them.

Any modification of the fire before the First Responders arrival must be documented. It is important for any following investigation, that nothing inside, or outside the fire scene is moved unnecessarily.

The activities by the Fire Department will impact on the fire scene, and there is a risk that some objects (such as doors and windows), may be damaged. All items that are moved, damaged, or removed, must be photographed and recorded (with the time and date), before being disturbed.

Take precautions that the fire scene is not contaminated by using PPE (personal protective equipment) in the form of examination suits, gloves, masks, etc. The owner / injured person should be informed that the fire scene is closed due to further investigations, and that the site cannot be visited until the site has been released by the police.

For urgent intervention in the building (for example disconnection of electrical/gas installations in order to ensure the electricity is disconnected for safety purposes and that the fact is recorded), this must be done by authorized personnel. An electrician must be advised that the fire scene is not to be visited without the permission of the police. If there is a need for disconnection, this must only be done in extreme emergency situations, and the police must document the electrician's actions. If a cable is to be disconnected, this must be done as far away from the fire scene as possible.

The electrician must also be aware that disconnection of the power to the fire scene may be of major importance to the investigation. He/she must be made aware that the changes - including the number of connections of current, must be documented.

The electrician must also be informed that changes in the electrical board, including replacement of fuses, may also have a major impact on the fire investigation. This also applies to power boards located outside the enclosed area. Securing groups and fault breaker status (on / off), shall be recorded before making any change in the electrical board. If it is necessary to change fuses, they must be marked with the location where they were taken, and either remain at the board, or handed to the police. The same applies to cables when disassembled. The above also applies to gas installations.

All elements which could be potential evidence, must be photographed and recorded at the original position, and thereafter, removed or protected, in order to clear a path for gaining access to the fire scene. This path must be clearly marked, and is to be used by all staff to get in and out of the area.

Obtain the existing hazard and risk assessment from the fire brigade and similar expertise.

See Appendix A2 section 14, together with Appendix A2 section 17.

5.1.5 Communication and coordination.

The First Responder, can contact the fire investigator / specialist for advice, prior to their work on-site. This may, for example, be about:

- Interpretation of available information
- Assessment of health and safety issues and risk assessment due to the Fire Departments incident response. The Incident commander from the Fire Department can give advice about risk assessment around the fire site. The risk assessment can include issues of crash hazard and hazardous substances, such as asbestos at the fire scene.
- Dialogue could concern:
- Strategy for the investigation
- Demarcation
- Sampling and hypothesis
- Presentation of investigation results.

This dialog can also include identification of relevant persons for obtaining information, as well of information that may be needed at a later date.

5.2 Tactical information

Information from others, both internal and external, can support the investigation in two main scenarios: Small, and comprehensive, fire damage. There are two types of tactical information (i.e., from persons, and from information), that can be extracted from technical systems.

The tactical information may include photographs, videos and/or information from the extinguishing efforts (such as whiteboard plotting). See Appendix A2 appendix B. Consider if there can be data collected from the various technical systems. Fire investigators are interested in:

- Drawings and plans (i.e. gas, electricity, structural, building and construction)
- Information about specific electrical equipment
- Information about standard procedures and deviation logs
- Data logs and maintenance logs
- Regulations (new and old)
- Manuals for equipment and objects
- Communication logs, including emergency calls / event notes
- Technical literature

5.3 Technical examination

When the fire has gone out, and the temperature is lower, an assessment of the further course of action will be carried out, and thus conduct a review of the case. The first orientation of the case is typically carried out based on the tactical information provided by the Fire Department.

5.3.1 In general

The documentation including photographing of the outdoor area should be made so that it is possible to identify the exact location of the fire scene, relative to the surroundings. This will include the surrounding area, such as adjacent buildings, and relevant parts of the surroundings. Photos taken from different positions, and a series of sequential photos, can be used to set different areas in a context. Also, rooms that are smaller or less / not burnt must also be photographed and documented. The First Responder, decides what and how to document, for example:

- Drone photo / 360-degree photo
- Overview photo / wide angle, exterior and interior
- Photo of sub areas

- Close-up photo / macro (details), e.g. most severe fire damage, lowest fire damage

The technical investigation should primarily be based on the physical evidence at the scene of the crime scene.

5.3.2 Initial discussion

If possible, gain access to a nearby building, or use the fire department's ladder or a drone, to view the damaged building from above. From above, it may be easier to see the way the fire has spread (for example the roof of the building and where it has been ventilated).

If you suspect an explosion has occurred, you must request assistance from an expert in the field. A well-considered access to the fire scene should go from surrounding areas, to exterior parts of the building, the doors and windows, and then inside and to any injured people, see figure 2.



Figure 2 A well-considered access to the fire scene should be followed.

5.3.3 Documentation and plotting

The documentation can also be made from relevant plans, drawings and sketches. External documentation should include appropriate features to identify the exact location of the scene. In addition to this, plotting of the fire scene should be undertaken. A photo of the plotting process contributes to the retention of the process, and identifies the choices made during the scene investigation.

5.3.4 Surroundings

Other buildings, for example garages and storage rooms, cabinets used to store cleaning materials etc., should be checked for the presence of flammable liquids. If items of interest have been found, such as petrol bottles, bottles and matches close to the property etc., these must be secured according to the given guidelines. Consideration should be given as to whether the flammable liquids may be on site completely routinely/legally.

5.3.5 Exterior

Observe the fire damage and the soot that can be seen on the outside. It can be:

- Which facade was most damaged by the fire?
- What signs from the fire can be seen on the exterior walls, or the roof, or above windows and doors? Or is the soot burned away? Remember that soot can burn out at high temperatures.
- Where do you see fire patterns above the windows, and what does the fire damage look like? Normal fire vented out through a window can result in a fire damage or a soot pattern over the window, as a V-shaped pattern.
- Can the wind or ventilation, building design, the fire department's tactics / techniques, have influenced the fire patterns?
- Does the fire pattern interpretation show that the fire started inside, or outside, the building?

5.3.6 Doors, windows and other openings.

Glass and soot around the door and window openings, can give an indication of fire spread and ventilation. This can help to identify where the area of origin is. When cleaning the fire scene (both coarse and fine cleaning), pay attention to glass shards/fragments, and where they are, either in relation to the fire, and/or if they have been fire damaged/affected. Examine the broken glass from the windows, and those located in and outside the building. Consider if the window has been broken from the inside of the premises, or from the outside, as well as before or after the fire.

Consideration should always be given to access/egress by a perpetrator and that these areas should be examined by the appropriate agency if a non-accidental fire is identified.

5.3.7 Internal examination as well as examination of fire injuries to people and fatalities. It is important to examine all areas, access roads, and undamaged space, to find and collect forensic traces associated with the fire. This can provide information that can help identifying the offender, and other persons involved. These traces are usually found outside the area of the biggest fire damage.

- Examine the fire damage on the building.
- How has the fire damaged the walls, ceilings, floors etc.?
- How and where were people injured by the fire, or, died due to the fire and/or smoke?

Always check all rooms and spaces, although they do not seem affected by the fire.

5.3.8 Extent and demarcation of investigation.

At the start of the investigation, where the origin is being sought, the entire fire-affected area of the building must be considered. As the investigation progresses, this area can be reduced. The area of origin can vary in size depending on the level of fire damage, and how difficult it is to interpret the fire patterns.

In all fire investigations, there must be a well-defined area of investigation. Any decision on the limitation of the area of investigation, should be clearly described. The reason for this is that there must be a validated base of tactical and technical information in connection with the fire pattern interpretation.

5.3.9 Clearing the fire scene.

In order to determine the location of the area of origin, it is important both to conduct rough clearance, and fine clearance of the area of interest. This is done by removing residues from the building structure and other parts from the surrounding area, to find the original structure/construction/content of the area of origin.

There are several different types of clearance that can be used. The most appropriate method will be determined by the decision taken by the investigation strategy. Clearing of the fire scene may be limited by time, weather, and any degradation of the fire scene. First responders are responsible for either not cleaning up too much, or cleaning up too little.

There are several methods when it comes to the actual cleaning of a fire scene. The basic method is to remove layers and fire debris by:

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

During the scene clearing the First responders must try to identify the location of furniture and any objects to the area. This will provide information on the extent of fire damage and can provide a more precisely defined area. Notice any odours of flammable liquids and / or other special odours. The First responder must ask for assistance from fire investigators if there is a need for machines for clearance, with or without assistance from an external work team.

6 VALIDATION AND ESTIMATION OF UNCERTAINTY OF MEASUREMENT

Methods should be documented and factors that must be considered in the study:

- sampling and its precision
- bias, margin of error
- field of work (detection / sensitivity), and suitability (in terms of environmental

- conditions)
- competence development of staff

Where relevant, reference should be made to key sources of uncertainty, as well as reporting uncertainty.

7 QUALITY ASSURANCE

First responders are advised to take part in relevant collaborative exercises and/or proficiency tests periodically, so that their competence can be demonstrated.

8 HANDLING ITEMS

The general recommendation is to preserve the scene, and thereby, the evidence. In other situations, the advice may concern the correct actions to take when deciding to remove or preserve potential evidence. If any items are moved from their original positions, this must be contemporaneously recorded.

If there are any question regarding the handling of items, the First responder may contact the fire investigator for advice, prior to their attendance at the scene.

The First responder, if possible, is to determine whether any potential evidence has been removed/alterd prior to their arrival. It is important for any further investigation, that all activities are recorded, and that this information is given to any subsequent investigators. (See Appendix A2 appendix B). Such information should include:

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

9 INITIAL ASSESSMENT AND DOCUMENTATION

9.1 Point of origin and fire cause

Before concluding the fire cause, there is a need to make an assessment regarding the fire scene(s). That is the reason why one must document all the objects in the current area that may have caused the fire.

General questions under hypothesis formulation and verification may be:

- The facts we know about the time of event and the burns we observe - do they match?
- Are the fire patterns (in general), as expected with the specific arena?
- What fire remains/debris and traces are found in the area of origin, which can be a technical evidence of the fire cause?
- How did the fire develop?

9.2 Management of the secured material/effects

It is generally recommended to maintain the fire scene, and thus traces and effects. If this is not possible, the advice may identify the correct procedures in order to ensure (remove/maintain), the potential effects of evidence. If it has to be moved from its original position, they materials/effects must simultaneously be documented. The First responder can expect fire investigators / specialists to contact them to clarify what has been removed, changed, or preserved.

Keep in mind that it may be necessary to protect and document other forensic evidence before they are removed/destroyed from the fire scene, i.e. fingerprints, glass, tool marks,

shoeprints, tire prints, fibers, blood (including blood patterns). All photos may be recorded in a log and / or by plotting, where each photo is numbered and tells where it was taken, and the recording direction. Any notes and other documents drawn up during the investigation should be stored so they can be retrieved at a later date in accordance with local requirements.

For investigation of a fire scene, one must bear in mind that there may be other forensic investigations to be carried out, such as securing of fingerprints, fibres, blood, etc. All work must be carried in conjunction with the relevant best practice guidelines. Coordinate and document all activities on-site as needed. For specific packaging requirements, refer to the relevant and current recommendations. Secured items will most often be examined by an accredited institution.

Traces and samples that may be of interest, could be cigarette butts, candles, fireworks, and objects in the scene area. These may be of importance when hypotheses of fire cause are to be verified. It may also be necessary to secure other items, such as fixtures or furniture, for further investigation or testing. Advice on this can be obtained from a specialist. The samples must not be destroyed without permission from a competent authority, in that they may be subject to further study

9.3 Assessment

Results from the fire scene examination should be assessed and verified from the fire investigator's own knowledge, experience and expertise. The investigator sets out a number of hypotheses based on technical evidence, observations, information, and their interpretation of the fire scene. Each of these hypotheses must be verified, resulting in a stable conclusion that allows for a determination of the point / area of origin, the fire cause, and the fire spread on the scene.

Fire investigation shall include the following points:

- Determination of the fire development
- Determination of the origin for the fire
- Determination of the cause of the fire and source of ignition

A preliminary work hypothesis (or hypotheses), based on empirical data, should be developed to clarify the cause of the fire, and the fire development. The hypothesis (or hypotheses), will be based on:

- Observations made at the fire scene (fire patterns, fire dynamics, results of any technical studies)
- Residual physical evidence (ignition source(s) etc.)
- Other information from persons and technical systems (tactical information)

Any hypothesis formulated about the fire cause (i.e. the first ignited material, ignition source, and ignition sequence), must be based on a review of the observations. Those factors are derived from evidence, observations, reliable witness information (calculations), experiments, and scientific laws. Guess or speculation must not be included in the hypothesis: Below are some examples of questions to consider:

- Is there a point of origin in item A or not?
- Is the hypothesised ignition source sufficient to ignite the first ignited material?
- Is the time required for ignition in accordance with the event sequence?
- What were the circumstances that allowed the ignition source to come into contact with the first ignited material?
- If there were errors, what did these consist of in order for ignition to occur?
- Are the fire patterns as expected, with the information available, and with verified hypothesis? Has the furniture (for example), protected the floor or the wall? Do the

fire patterns on the furniture show that the fire burned from a certain direction?

When the hypothesis seems to be consistent with the findings and all research (if available), it becomes a final hypothesis that can be presented by the researcher's conclusion. The origin can be described as an interpretation of the damage caused by the fire. The tools used in the investigation of a fire scene are the ability to recognize, interpret, identify, and analyse these fire patterns.

In case of fire, you should be aware of fire patterns and traces left by a possible perpetrator. When investigating cases of arson, it is sometimes possible to find patterns / traces left by the perpetrator on the scene that demonstrate their route in, or around, the fire scene. Note that in heavy fires, many of these patterns do not survive.

10 HEALTH AND SAFETY

See Appendix A2 section 14, together with Appendix A2 section 17.

11 REFERENCES

References are given in Appendix A2 section 15 References. There is no requirement to repeat these within the guideline.

12 AMENDMENTS AGAINST PREVIOUS VERSION

The practical guide for First responder has been changed accordingly to the guidelines for ENFSI guide, and has also been synchronized with the Appendix A2 Practical guide for Fire Investigators and specialists. This means that there are new sections, new fonts, and updated sections coherent with the scientific method of performing an investigation at a fire scene as the First responder.

APPENDIX A2 – FIRE INVESTIGATIONS FOR FIRE INVESTIGATORS AND SPECIALISTS

This guide is the result of a unique collaboration and would not have been possible without participation from the following institutes and guest members.

Bundeskriminalamt	Austria
Institute of Criminology	Czech Republic
National Center of Forensic Services	Denmark
Danish Institute of Fire and Security Technology	Denmark
National Bureau of Investigation	Finland
Institut de Recherche Criminelle de la Gendarmerie Nationale	France
Netherlands Forensic Institute	Netherland
Bayerisches Landeskriminalamt	Germany
Police	Israel
Fire and Rescue Research centre	Lithuania
Forensic Science	Northern Ireland
National Criminal Investigation Services	Norway
National Forensic Laboratory	Slovenia
Portuguese Forensic Laboratory	Portugal
National Forensic Center	Serbia
Catalonian Police	Spain
National Forensic Center	Sweden
Ecole des Sciences Criminelles, Lausanne	Switzerland
Police Cantonale Neuchateloise, Service d'identification judiciaire	Switzerland
Forensic Science Service	UK
CAHID, University of Dundee	UK
Scottish Police Authority Forensic Services	UK
Key Forensic Services Limited	UK

You can find the latest version of this guide on the ENFSI website (www.enfsi.eu).

Fire and Explosion Investigation
Working Group Fire Scene Investigation
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Responsible for this revision can be seen below. If you have any comments, additions, suggestions or remarks you can contact them.

Eva Ljungkvist eb1006@politi.dk

Benny Thomsen bth005@politi.dk

Both from Danish National Police, National Forensic Services

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1 AIMS

This practical guide aims to provide a framework for fire and explosion investigators and specialists, both from the public and private sectors. It offers recommendations for how to investigate at the scene of a fire and/or explosion in order to achieve the best possible results.

A fire and explosion investigator is someone who is involved in determining the origin, cause and development of a fire and/or explosion.

This work brings together current available knowledge and material and is the result of an extensive study of current practice used by forensic science laboratories and institutes throughout Europe.

The term 'practical guide' does not imply that the practices laid out in this manual are the only acceptable methods used in fire scene investigation.

2 SCOPE

This guide provides specific information for the fire investigators in order to ensure that specific initial information is not lost. There are five broad phases of activity covered here (figure 1) and, for each phase, the role of the fire investigator is explained.

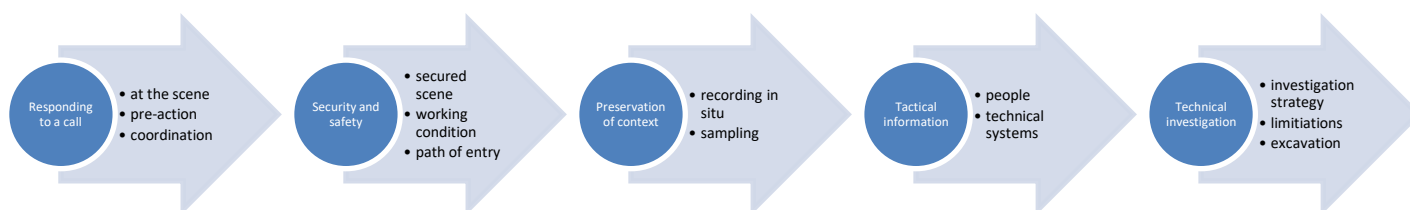


Figure 1 Stages of an investigation

The different phases should not be considered separately and, during some investigations, there is no strict chronological order in which they must be done. They are interwoven and the activities in each phase can link into others.

People involved in the investigation of fires are divided into three levels and can all be involved in determining the origin, cause and development of a fire and/or explosion:

- First responder
- Fire investigator
- Specialist

The boundaries between each of the different levels are not clearly defined. Each fire has its own challenges and a fire investigation, which initially seems simple, can turn out to be very complicated and may need to be dealt with by a specialist.

This document is a guide and must be used in conjunction with other reporting guidelines, procedures and documentation required by specific national legal and investigative authorities. This may include for example health and safety protocols and legal requirements of expert witnesses.

It is important that you know the limitations of your knowledge and expertise. It is better to ask an appropriate specialist for assistance than to carry on, risk in failing to identify a crime due to an inaccurate or an incomplete investigation or making mistakes and potentially contribute to a miscarriage of justice.

3 DEFINITIONS AND TERMS

For the purposes of this practical guide, the relevant terms and definitions are given in ENFSI documents and other relevant documents², other relevant and specific definitions are presented in chapter 5 - METHODS.

Definitions of involvement and different phases of the investigation (for details, see *Appendix 1 Investigation phases*)

Name	Definition
First responder	The first 'official' person or agency who responds to the scene (i.e. police, fire service).
Fire investigator	People who are called in by the first responder or the investigating agency when the fire investigation is considered to be more complex.
Specialist	People who have special competence or knowledge combined with specific experience and expertise in their chosen field. The specialist is called in by the fire investigator or by the investigating agency.

4 RESOURCES

4.1 Personnel

The fire investigator(s) and specialist(s) must verify that they have demonstrable competencies and experience that are relevant to the task at hand.

A conclusion will qualify as scientific findings if the fire investigator/specialist can demonstrate that it is the product of a sound scientific method.

The 'scientific method' is the process of formulating hypotheses and then conducting experiments/analyses to provide support for or against the hypothesis that is considered relevant at the time. This may lead to the formulation of further hypotheses as the process is repeated.

The fire investigator and the specialist are qualified as an expert by knowledge, skill, experience, training and education and may give evidence in the form of an opinion, or otherwise if:

- The expert's scientific, technical, or other specialised knowledge will help the court to understand the evidence or to determine a disputed fact.
- Their testimony is based on sufficient facts or data.
- Their testimony is the product of reliable principles and methods.
- The expert has reliably applied the principles and methods to the facts of the case.

4.2 Equipment

See Chapter 5 – Methods.

4.3 Reference Materials

See Chapter 15 - References.

4.4 Facilities and Environmental Conditions

See chapter 5 - Methods and Chapter 14 - Health and Safety.

4.5 Materials and Reagents

Not applicable.

4.6 Allocation of Responsibilities

All activities, involving scene preservation or the protection/recovery of potential evidential

² (Bell, 2012), (De Haan & Icove, 2012), (Drysdale, 2011), (National Fire Protection Association, 2014)

material, must be communicated to the appropriate people/agencies as soon as practicable. When assistance is required in specialised fields, expert advice must be sought. Where assistance had been sought, any specialists involved should, if required, have experience of fire scenes. See Appendix 1 - Investigation Phases.

The following is a selection of experts who *could* be of assistance during fire scene investigations:

- Forensic Science Laboratory
 - electrical, chemical experts
 - gas and mechanical experts
 - fire protection engineers analysis
 - heating appliances and chimney experts
- Fire and Rescue Service. Can assist in the fire investigation at the scene and in drawing up a statement of risk for the fire spread.
- Forensic anthropologist, can assist in body recovery at fire fatalities.
- National Electrical Safety Board, or similar, can assist in the fire investigation at the scene.
- Medical examiner/pathologist can assist in identifying bodies and examining suspects.
- National Maritime Administration can assist in drawing up statement on risk for fire spread on ships.
- Chimney master/sweeper can assist in fire investigation at the scene.

The fire investigator must also consider what parties to inform when it comes to fire protection programs, i.e. product manufacturers, insurance companies etc.

4.7 Collegiate Approach

'Collegiate approach', means an investigation team composed of various colleagues of equal standing, for example:

- Forensic fire investigator
- Forensic Locksmiths
- Forensic motor vehicle examiners
- Forensic electrical engineers
- Claims Staff
- Private sector investigator

A collegiate team approach is a good way to maximise the identification of the full scope of the available physical evidence and can assist in ensuring the identification of the origin and cause of deliberate fires, where possible.

5 METHODS

5.1 Responding to a Call

The fire investigators are not normally directly involved in this phase of an incident. They must ideally obtain the "data collection sheet" or similar information from a first responder and liaise with him or her to obtain relevant information prior to attending the scene. See Appendix 1 - *Investigation phases*.

5.1.1 En-Route and approaching the scene

En route and near to the scene – information to be recorded / obtained:

- 1) The time of call and any information initially given
- 2) People present (witnesses, bystanders, reporters, others)
- 3) Vehicles present
- 4) Anyone seen leaving the scene as you approach.
- 5) Strange or specific activities of any individuals present

- 6) The prevailing weather conditions: (general wind speed and direction as well as any changes in weather). This information can, in some cases, help to explain the spread of fire.

Approaching the scene - information to be recorded / obtained:

- 1) Your activities (safety assessment, evacuation/rescue of personnel and extinguishing the fire).
- 2) The number of fire appliances in attendance and the activities of fire fighters.
- 3) Those who were present as bystanders, particularly if they seemed to be especially interested or if they showed unusual behaviour. Photographing and filming bystanders can also be useful. Ensure that all photographs and videos are documented, dated and retained.
- 4) When the owner arrived at the fire scene and their reactions to receiving the information relating to the incident.

5.1.2 At the Scene

Take appropriate photographs and make suitable notes as soon as possible in order to fully record the scene. Photographs and notes must include all angles and aspects of the scene, including areas which may not be on fire at the time.

Take photographs of the fire fighting activities, paying particular attention to the location of smoke and flames when you arrive. Recording the incident using video is also useful. Ensure that the video is dated and includes the correct time.

5.1.3 General Information for Documentation

At this stage it is possible to start collecting information from the incident commander (or equivalent) and the fire fighters. You can also obtain valuable information from witnesses and the property owner at an early stage. Complete the relevant parts of the data collection sheet. See Appendix 2.

5.1.4 Initial Scene Preservation

Any modification to the scene before arrival of the fire investigators must be recorded and well documented. This evidence needs to be recorded correctly before any change takes place. Sample protection, particularly where DNA may be critical such as blood, lids, bottles etc. the First Responder needs to ensure that the recovery method or protection is carried out in a forensically accepted manner and does not contaminate the article.

It is important for any subsequent investigation that nothing within or outside of the scene is moved unnecessarily. While it is recognised that firefighting activities will result in the movement and/or damage of some objects (e.g. doors and windows to gain entry) the removal of any objects from the scene must be minimised. Any items which do need to be moved, damaged or removed must be photographed and noted (with the time and date) beforehand. Be aware that trace evidence, not visible to the naked eye (i.e. DNA and fingerprints), can be left at the scene by first responders. Appropriate anti-contamination precautions must therefore be taken (i.e. forensic scene suits, gloves, masks etc).

5.1.5 Communication and Coordination

Be aware that the first responder may contact the fire investigator for advice prior to their attendance at the scene. Such advice may include identifying relevant people to speak to and the type of information that might be required at a later stage.

All activities undertaken involving information gathering must be communicated to the appropriate specialist as soon as practicable. All investigation work at the scene needs to be coordinated and communicated with all parties.

5.2 Tactical Information

The fire investigator or specialist may find themselves with two general situations after a fire:

- 1) Fire propagation is limited and it is therefore quite easy to locate the origin of the fire.
- 2) Severe or complete destruction of a property. Extensive excavation may be required to determine the seat of the fire.

The information gathered by others (i.e. the police officer, the fire service and the first responder) can help the investigation in both of these scenarios. Figure 2 is an example of useful topics to discuss.



Figure 2 example of tactical information issues

There are two types of background information – information from people and information which can be extracted from technical systems. See *Appendix 2 Background information*.

5.2.1 Information from People

Obtain the data collection sheet (or equivalent) filled out by the first responder. If this has not been completed, ensure that you gather the remainder of the required information. This may include photographs, videos and/or incident recording (i.e. white board plotting). Any additional enquiries must be recorded. Many additional questions are raised during the investigation. It can therefore be helpful to ask the incident commander and/or fire fighters to come to the scene, and account for their observations and actions in situ.

Check with press photographers and TV companies to see if there are any pictures or videos, taken at an early stage of the fire, which have not been published. These can be very useful in helping to establish the point of origin. Social media can also be an important source of information and thorough search routines are recommended. A timetable (i.e. STEP analysis) of important events before, during and after the fire should be prepared.

5.2.2 Information from Technical Systems

Consider interrogating any suitable technical system and, if it connects to a remote call station, obtain the data logs. These logs may contain detailed information relating to the activation times of the individual detectors, thus allowing the investigator to map the spread of the fire. Some information is time dependent, such as CCTV, smart electric meters and alarm (fire or burglary) system information and must be documented and recovered by an appropriate person.

Some key information sources to consider are:

- Pre-existing drawings and plans (i.e. gas, electrical, structural, building construction)
- Information about specific electrical equipment
- Process information and standard operating procedures
- Data logs and maintenance logs
- Licences
- Regulations and norms (new and old)
- Equipment manuals
- Radio traffic
- Emergency calls
- Technical literature

All activities undertaken involving technical information gathering must be communicated to the appropriate specialist as soon as practicable.

5.3 Technical Investigation

5.3.1 General

Prior to, or upon arrival, the fire investigator may be required to give advice regarding preservation of the scene, i.e. fire fighting activities and coordination of scene commanders.

As part of the scene examination, a series of general photographs and videos could be taken as well as acquiring or preparing appropriate plans, drawings/plottings and diagrams. Videos can also be taken. Correct documentation and photography is essential. Exterior documentation should include appropriate landmarks in order to identify the exact location of the scene. It should also include the general surrounding area, e.g. adjacent buildings/structures, and angular views of the exterior of the scene. Multiple views and a series of sequential photographs can be used to contextualise different areas of the scene.

Documentation must also include notes of your observations at the scene and any actions you carried out. These documents must be signed, dated and retained, all according to local regulations and national laws, so that they are able to be retrieved and reviewed at a later date, if necessary.

For further details, see chapter 3.2 - *Recording in Situ*

5.3.2 Interpretation of Available Information

Information may be received from the first responder(s), or from others. It could tell you what occurred prior to, or during the fire and may provide guidance regarding areas of more or less interest to the scene investigation.

All technical investigations must primarily consider the physical evidence at the scene. Treat any witness information with caution as it could be incorrect or misleading. Be alert and verify whether or not it was possible for the witnesses to have observed what they claim to have seen from their original locations.

To optimise the quality of their interpretation, the fire investigator needs to use a scientific method³ during their examination. This can include (where appropriate):

- Assessment of the fire scene
- Validated analysis (i.e. STEP⁴, ACCIMAP⁵)
- Appropriate use of technical methods (i.e. hydrocarbon dogs, lab tests, fire experiments)
- Hypothesis testing

³ The overall process of a scientific method involves making hypotheses, deriving predictions from them as logical consequences and test them by carrying out experiments/analyses.

⁴ Sequential Timed Event Plotting

⁵ Systems-based technique for accident analysis

5.3.3 Investigation Strategy

The main focus of fire scene examinations is on fires in buildings. However, the same general principles apply to the majority of all fires that will be investigated.

- Agreed and co-ordinated strategy for the forensic investigation
- Safety protocol for working conditions

Each scene investigation must be planned carefully and as soon as possible. Before entering, it is of extreme importance that you are fully aware of all the relevant, known circumstances relating to the fire. Make sure that you are familiar with relevant background information gathered by the first responder(s), fire fighters etc.

If you need more information, you must get it before you start the scene examination, where possible. This will help you to plan the investigation. Starting the examination with a lack of information can result in a poor investigation and there is a risk of accidentally destroying evidence. See *Appendix 1 Investigation Phases*.

It is recommended that the investigation is carried out in teams, where possible. Depending of the nature of the scene, these teams can comprise different types and numbers of people. Ensure that every team member is aware of his or her role (i.e. evidence collector, photographer etc.). Make sure that your tools and equipment (including PPE) are clean, correctly functioning and ready to use.

It is recommended that at least two fire investigators are present at the scene so they can support each other and keep each other from taking a blinkered approach. Each fire investigator must be comfortable with the type of investigation they are carrying out and must not be afraid to 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. This is carried out by collecting and recording data through the detailed examination of the scene.

This information is then evaluated using the investigators own knowledge, experience and expertise. From this, the investigator sets up a number of hypotheses based on the evidence found at the scene.

Each of these hypotheses is suitably tested, resulting in a robust conclusion or conclusions, allowing an accurate determination of the origin, cause and fire spread at the scene.

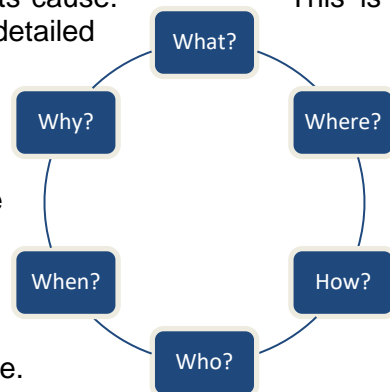


Figure 3

The fire scene investigation must cover the following points (Figure 3):

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

The technical investigation focusses on the above but will also aid where possible, the investigation as to WHO? and WHY? (i.e. the motive).

5.3.4 Initial Overview

If possible, try to gain access to a nearby building, use a fire service ladder or a drone, to look at the damaged building from above. From a higher vantage point, it can be easier to see the way the fire has spread and where it breached/vented through the roof.

If you suspect that an explosion has occurred, consider referring to the Explosion

Investigation guide⁶ alongside this one. A structured approach to the scene investigation should be followed (figure 4).



Figure 4

5.3.5 Surroundings

Other buildings, garages, storerooms and cupboards used to store cleaning materials should be checked for the presence of ignitable liquids. Are any objects of interest, such as petrol cans, bottles and matches found close to the property?

5.3.6 Exterior

Study the signs left by the fire on the exterior of the building:

- Which facade was most damaged by the fire?
- What does the outer wall or roof above the windows and doors look like? Is it covered in soot or has the soot burned away? Remember soot can be burned away at high temperatures.
- Which windows have fire patterns above them and what do they look like? Normally, fire venting from a window, results in a fire damage or soot pattern above the window in the form of a 'V' spreading upwards.
- Could the wind or ventilation, the building construction, the fire service's tactics/techniques have affected the evidence left by the fire?
- Does the evidence left by the fire suggest that the fire damage has been caused by a fire inside or outside the property?

5.3.7 Interior, Fatalities and People

It is important to inspect all areas, access routes, and undamaged rooms to find and collect forensic clues associated with the fire. Clues as to help identify the perpetrator are often found outside the scene. Is there any evidence of another fire (or fires) somewhere other than close to the point of origin?

- Study the evidence left by the fire on the building.
- How has the fire damaged the walls, ceilings, floors etc?
- How and where have people been injured by or fatalities been caused by the fire?

Always inspect all rooms and spaces, even if they don't seem affected by the fire.

5.3.8 Glass Panes and Openings

Glass and the soot around openings can provide an indication of the fire spread and ventilation. This can help lead you to the seat of the fire.

During the rough and detailed excavations, pay attention to where pieces of glass lay in the remains. Study pieces of broken glass from windows; both those which remain in the frame and those which are lying inside and outside the building.

Consider whether the window has been broken from the inside or from the outside. Or take a sample for comparison purposes, especially if a suspect has been arrested and it is thought that a window may have been broken to gain access to the building.

5.3.9 Setting the Physical Boundaries of the Area of Investigation

The point of origin (or seat) of the fire is the place or places where the fire started. In principle, the whole area in the building, affected by fire, must initially be considered. As the investigation proceeds, this area may reduce. The final area/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 fire remains.

⁶ referring to dispersed phase and mechanical explosions

In any fire investigation there will be a well-defined area of investigation. Any decision as to where the physical boundaries of the investigation lie must be clearly recorded. The reason for this is found in the interpretation of fire patterns, validated background and technical information.

5.4 Excavation

In order to determine the seat of fire/point of origin, it is important to excavate the area of interest. This is carried out by removing fallen debris and other items from the surrounding area to reveal the original content of the area of origin. This involves removing layers in a systematic manner, similar to an archaeological excavation⁷.

There are several different types of excavation that can be used. The most appropriate method will be determined by the particular fire investigation approach being taken at the time. The approach can be limited by time, weather and decomposition of the fire scene. Routines are to be used in:

- Single context recording system (see details in chapter 4 *Preservation of context*)
- Stratigraphic excavation
- Physical methodology of excavation

The fire investigator in charge is responsible for ensuring that under-cutting⁸ or over-cutting⁹ is avoided during the excavation.

5.4.1 Stratigraphic Excavation

Stratigraphy is a key concept in modern archaeological theory and practice. Modern excavation techniques are based on stratigraphic principles, as applied to fire investigations; Original horizontality and Lateral continuity

The best practice of stratigraphic excavation, in its basic sense, involves a cyclical process of “trowelling back” the surface at a fire scene. The excavation must start from the outside of the area and proceed inwards, towards the presumed point of origin, in order to preserve any evidence on the way. Excavation follows from the area of least damage to the area of most damage in this way.

5.4.2 Physical Methodology of Excavation

The process of excavation can be carried out in many ways. The basic method is to remove layers and items by:

- Working from the known to the unknown
- Working from the top to the bottom
- Using all senses in the process!

During this process one should be able to establish the location and layout of the furniture, its composition and what other materials are present. This will provide information on the patterns of burning and can allow the area/point of origin to be refined further. It is during this stage of the excavation that odours of ignitable liquids and other specific smells may become apparent.

5.4.3 Mechanical Excavation and Organisation of Workforce

There are several different machines to aid excavation, when it comes to type, size and function. Using a mechanical excavator is the quickest way to remove non-critical debris (i.e. fallen roofing or walls) and to prepare the surface for closer excavation by the fire investigator. It is also possible to get some help from a work team - “*muscles and shovels*”. Before a work team is allowed in the fire scene there is a need to go through the basic protocol for:

⁷ EAC Guidelines 1, D/2014/6860/017

⁸ Contexts are not excavated fully and some remainder of context is left in situ masking the nature of the underlying contexts.

⁹ Contexts are unintentionally removed from i.e. the point of origin.

- Security and safety.
- Preservation of evidence.
- Excavation.

When using mechanical excavation, with or without the addition of a work team, it is even more important that the fire investigator has a detailed excavation strategy and supervises the working progress closely.

5.4.4 Cause of the Fire

In order to establish the cause of a fire you should normally have determined a point/area of origin beforehand. Document all possible objects within the previously identified point/area of origin that could have caused the fire. Call in appropriate specialists or recover and send items of interest to them. If items are to be sent to specialists, or if specialists are to visit the site, it is beneficial for the items to remain in exactly the same state as when they were discovered. See *Appendix 3 – Examples of Fire Causes (Figure 5)*.

General questions (in no prioritized order) to ask throughout the hypothesis testing are:

- How probable are the damage patterns like observed, assuming the different possible fire causes and fire origins respectively?
- Does the fire damage pattern (in general) agree with the point of origin being in this area?
- What remains in the area of origin (consider samples to analyse)?
- What was the ventilation like? How did the fire develop?

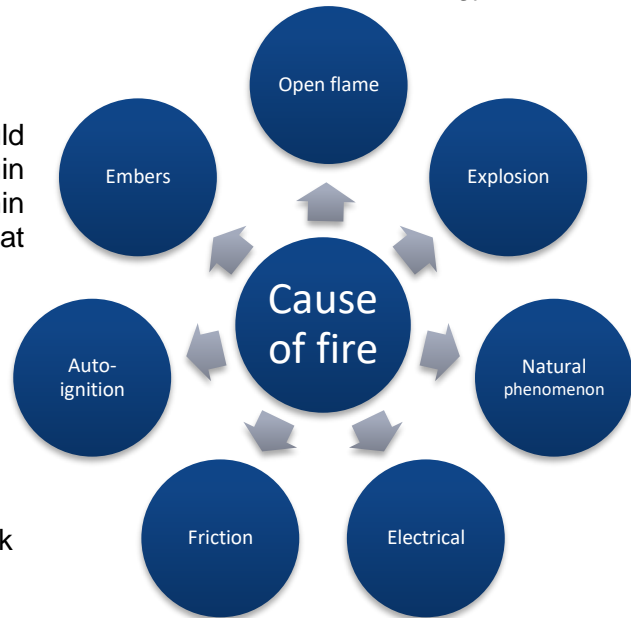


Figure 5

6 VALIDATION AND ESTIMATION OF UNCERTAINTY OF MEASUREMENT

6.1 Validation

The minimum requirements for considering a method validation (and where appropriate, software validation) should be outlined. Some factors to be considered include, as appropriate, sampling, precision (repeatability, reproducibility), bias (matrix/substrate effects, specificity), working range (limit of detection/sensitivity, linearity), robustness (environmental susceptibility) and competency of personnel.

6.2 Estimation of uncertainty of measurement

Where relevant, guidance should be provided on identifying and quantifying the main sources of uncertainty and reporting the uncertainty and the intra variability of the possible fire developments.

7 QUALITY ASSURANCE

Fire investigators are advised to take part in relevant collaborative exercises and/or proficiency tests periodically so that their competence can be demonstrated.

8 HANDLING ITEMS

8.1 At the Scene

As a first responder the “ENFSI Fire and Explosion Investigation practical guide for first

responders to fire scenes” provides a comprehensive methodology.

8.2 Preservation of Evidence

8.2.1 Dialogue with the First Responder

Be aware that the first responder may contact the fire investigator for advice prior to their attendance at the scene. The general recommendation is to preserve the scene, and thereby, the evidence. In other situations the advice may concern the correct actions to take when deciding to remove or preserve potential evidence. If any items are moved from their original positions this must be contemporaneously recorded.

Upon arrival at the scene, the fire investigator should liaise with the first responder, if possible, to determine whether any potential evidence has been removed, altered or preserved prior to their arrival. It is important for any further investigation that all activities are recorded and that this information is given to any subsequent investigators. (See Appendix 2).

Such information should include:

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

8.2.2 Recording In Situ

As part of the initial examination of the area, a series of general photographs and/or videos should be taken. In addition to this, diagrams of the fire scene should be made.

Exterior documentation should include landmarks in order to identify the exact location of the scene. This would include the surrounding area, e.g. adjacent buildings/structures, and angular views of the exterior of the scene, as appropriate.

Multiple views and a series of sequential photographs can be used to contextualise different areas of the scene. A mosaic/collage of photographs can be useful if a wide angled lens is not available.

360° photography, drones, 3-D recording and other scanning techniques could be considered as part of the recording process in combination with alternative light sources. Bear in mind that other forensic evidence may need to be protected and recorded prior to its removal, e.g. fingerprints, glass, tool marks, footwear/tyre marks, fibres, blood (including blood patterns), DNA, etc.

All photographs taken can be recorded on a log and/or diagram, detailing the number of each photograph, where it was taken and the direction from which it was taken. Any notes and other documents made during the scene examination must be signed, dated and retained so that they can be retrieved at a later date, all according to local regulations and national laws.

Even rooms, which are less badly damaged by fire or have no fire damage at all, should be photographed and documented.

8.2.3 Sampling

8.2.3.1 *General*

When investigating the cause of a fire, bear in mind that other forensic investigations may also be needed, such as fingerprints, fibres, blood etc. All work should be carried out according to the appropriate best practice manuals/guidelines. For specific packaging requirements, refer to the appropriate and current recommendations in your jurisdiction. Coordinate and document all activities at the crime scene as required.

Recovered samples will mostly be examined by a certified specialist.

Finding items of interest i.e. matches, cigarette butts, candle wicks, night-light (tea light) holders, wick holders etc. in the point of origin may be of significance when the cause of fire is to be determined by hypothesis testing.

It may also be necessary to obtain other items such as bedding or furniture for further examination or testing. Advice regarding this could be obtained from a specialist.

Samples must not be destroyed without authorisation from the appropriate¹⁰ body because they could be required for further examination.

8.2.3.2 *Ignitable Liquids*

If there is any suspicion that an ignitable liquid is involved in the fire, suitable samples should be recovered and preserved in appropriate packaging. Samples would normally be taken:

- from places where the liquid might have been protected, such as behind skirting boards, under doorway thresholds
- from the outer edge of a very burned area, the insulation between floors, cracks in the floor, floorboards etc.
- from items into which liquid may have been absorbed by capillary action, for example, flat surfaces such as table tops or the bottoms of drawers
- from areas where the liquid could have been adsorbed (i.e. charred materials near the point of origin)
- from below windows and external doors both inside and outside.

The fire investigator is duty bound to include the possible health risks inhaling some chemicals can raise and must wear proper protective equipment at all times. But throughout the investigation the fire investigator should be aware of strange smells, e.g. from possible ignitable liquids. This is especially important when dealing with materials that have the capacity to absorb liquid, such as cloths, carpets, paper, wood, etc. Any finding must be analysed in the lab to confirm.

Hydrocarbon dogs, electronic sniffer devices or alternative light sources can be used to help search for ignitable liquids.

When taking samples at a scene, it may be appropriate to take a reference sample. Some materials such as different kind of plastic foams, rubber mats and inks can contain chemicals that are also found in some ignitable liquids. As such, recovered samples may give a result that needs to be compared to a suitable reference sample to help with the interpretation of the result.

The samples must be placed in suitable packaging, as appropriate for your laboratory/country. Avoid cross contamination between taking each sample or use disposable tools when possible. It is recommended that disposable gloves are also used (and changed as necessary). Furthermore, be aware of any other sources of potential contamination, i.e. petrol-driven machines which have leaked fuel or oil and additives which may have been used in some extinguishing foams or waters. For the same reason you must remember to be careful if you use a petrol-driven electricity generator at the scene. Don't refill the generator with petrol inside the scene and use disposable gloves, which must be kept out of the scene.

8.2.3.3 *Bottles and Cans*

The contents of bottles and containers found at the scene should be considered for recovery and analysis. Even a seemingly empty container can be sent for analysis since traces of an

¹⁰ Normally the destruction of items is governed by the relevant legal procedures under which you are working. These can vary from country to country, by who has overall responsibility for the investigation (i.e. Police, Fire Service, etc.) and depending on whether the case involves any criminal or civil investigation. If you do not know what the relevant retention period is for any of the items taken from a scene, seek advice before doing anything further with the items.

ignitable liquid may remain in it. Remember that there may be fingerprints or DNA on the container. Liquid containers with some still in them must be well sealed and sent in as they are, or the contents should be decanted into an appropriate container. If a small sample of the liquid has to be taken, use a clean pipette rather than pouring the liquid out of the container. Sampling or decanting of liquid must be carried out away from the area of interest to avoid potential contamination.

8.2.3.4 *Technical Systems*

It is best for a relevant specialist to attend the scene and carry out these examinations. However, if this is not possible then advice must be sought.

During the investigation, note and photograph the positions of items which are particularly damaged by the fire. It may be beneficial (or necessary) to remove these items, along with part of whatever they are attached to (i.e. wall panels and the like).

- Make a record of the item in situ.
- Do not take the object apart.
- Note their orientations (i.e. which way is up and which is down).
- Do not touch any dials or knobs.

8.2.3.5 *Fatalities*

As long as the body and surroundings are not completely burned or charred, evidence may remain on the body, clothes or things nearby which can give valuable information about what happened before the fire. It may be useful to involve a Forensic Anthropologist in the excavation of the scene and body recovery.

If you suspect that an ignitable liquid was used to deliberately aid the rate of growth and extent the fire then you must take samples. To best preserve such evidence, one must take the deceased's clothes together with material from under the body, such as bedding, chair cushions, carpets, flooring, car seats etc. Loose clothing can be taken directly from where the body was found. Clothing, which can't easily be removed can be cut up and taken, but consider other possible trace evidence (i.e. fibres). In both cases clothing can only be taken as long as it doesn't affect the subsequent post-mortem examination. Remember to inform the pathologist what has been changed or removed.

8.2.3.6 *People/Witnesses*

Bear in mind that the police or insurance investigator may need to consider looking for evidence on a living person (i.e. a suspect) from the scene. The fire investigator and the specialist can give advice regarding potential evidence recovery and packaging.

Visible fire remains, which you think may be on a suspect's clothing, should be secured by carefully removing the clothing. Clothing and shoes may need inspection under a microscope to decide whether they have been subjected to flame wash or high temperatures. The entire garment must be taken whole, wherever possible.

Clothing and shoes that are taken must be packaged appropriately to preserve any ignitable liquid traces as soon as possible. The sampling of hands, if required, can be done by using the identified method within your country, such as using suitable gloves or absorbent material. The sampling is to be done as quickly¹¹ as possible. It is recommended that the sampling procedure is discussed with the laboratory beforehand.

A medical examiner should inspect the suspect's body as soon as possible to see if there are burns to skin, hand hair, eye brows, eye lashes, beard or head hair. Samples may be taken for further examination by a specialist. Scorching or direct burns to a suspect's body must be documented by photography.

8.2.3.7 *Documents*

If you find documents or bank notes during a point of origin investigation, which need to be

¹¹ Research, done by the National Forensic Center, Swedish Police, recommend that samples are taken within 3 hours of the start of the fire.

secured for subsequent examination, photograph them in situ and carefully place them between stiff sheets of cardboard and package them in a rigid box (a photograph box is suitable). If large quantities have been recovered then they can be packaged as they were found in a sufficiently large box. Make sure that the material is secured in the box during transport, so that it does not move about and damaged further. Damp material must be sent for investigation as soon as possible.

8.2.3.8 Spontaneous Combustion

When you suspect that spontaneous combustion has caused the fire you should take samples from the point of origin and also from less damaged areas where you suspect that self-combustible material is present. A specialist must be contacted for further advice and obtaining reference samples and any additional information needed.

8.2.3.9 Packaging and Removal of Fragile Items

If items need to be immediately removed from the scene, or are likely to become damaged, they should be photographed in situ and documented appropriately. Clearly show the location of the item in the building, vehicle or area from which it was taken. It is often appropriate to do this by taking photographs and marking the location on a fire scene plan. Sampling should be carried out as described in chapter 5.

Once removed, the items must be packaged appropriately and disturbed as little as possible. Items should be stored carefully to minimise damage and contamination, then signed over to the specialist, if necessary.

8.2.3.10 Maintenance of Sampling Equipment

When it comes to maintenance of the equipment used for sampling, each organisation and country should have detailed procedures as to how this is done. This should include details of what equipment is to be cleaned, how and how to clean it. It should also specify when to dispose of old equipment and when to only use fresh equipment. The manufacturer of each piece of equipment may be able to provide details concerning the lifetime of their product(s) and recommended cleaning schedules, if applicable.

8.2.3.11 In the laboratory

Not applicable.

9 INITIAL ASSESSMENT

See Chapter 5 - Methods.

10 PRIORITISATION AND SEQUENCE OF EXAMINATIONS

See Chapter 5 - Methods.

11 RECONSTRUCTION OF EVIDENCE

Carrying out a forensic reconstruction is a methodology which can deliver additional value to already known investigating results of examined traces (evidence) in forensic investigations and/or can give insight on how traces are donated or created (activity orientated).

The preceding sentence can be interpreted broadly and depends on the nature of the forensic investigation carried out. By means of a reconstruction, for example, the degree of probability of how and where an activity occurred can be strengthened or weakened. The results of a reconstruction can therefore influence the interpretation and the strength (value) of conclusions obtained from evidence.

The kind of the reconstruction can give direction about the necessary level of details and amount of information one could record. Subjects for registrations could be: the involved investigators, the detailed set-up of the reconstruction, technical aspects, registration of all matters which may have influence on the results, registration of the reconstruction

(photograph's, video) etc. The well documented reconstruction allows, if needed, a professional review afterwards.

After the excavation has been done, items that have been recovered from the area should be replaced in their original positions, if possible. This reconstruction must be compared to the owner's sketch of the area, if one is available. When this is done the investigator can continue with their interpretation of the fire patterns.

The reconstruction can be aided by features such as furniture marks on the floor and clean surfaces on the walls where objects have stood and provided protection. When the items have been replaced, they can be compared to the relevant fire damage patterns on i.e. the floor, the ceiling and walls, and the fire damage to furniture.

The fire investigator can carry out fire experiments in situ at the scene and/or in the laboratory. When performing scientific fire experiments in a laboratory, the recommendation is to use a certified one with clear documentation of standards.

There are several reasons for carrying out fire experiments in situ. As mentioned above, an experiment can be one way of testing a hypothesis. It can also help visualise the fire development or show a possible cause of fire. There are two main categories of fire experiments carried out in situ:

Single parameter

The purpose of this is to gain specific knowledge i.e. a naked flame will affect a specific item/materiel, such as a piece of a curtain.

Multi-parameter

The purpose of this is to reconstruct several parameters at the scene. The parameters can, for example, be the source of ignition, the fabric of the curtain (including facts as weight per m², thickness etc.) and so on. If the experiment is conducted outside, the general conditions should be the same as at the time of the fire i.e. wind direction, temperature etc.

When conducting fire experiments in situ is it important to meticulously document and photograph continuously. Factors to consider when setting up fire experiments in situ are:

- Geometric circumstances
- Narrowing down the parameters
- Choice of method
- Repeated experiments
- Structure of the documentation and quality control

Documentation of the reconstruction is essential. Photograph and video the cleared area, both with and without the items in place. Make a sketch of the rooms, noting the recovered furniture and any other items of interest.

12 INTERPRETATION

12.1 Analysis and hypothesis - Develop hypothesis

A preliminary working hypothesis (or hypotheses) based on empirical data should be developed to explain the fire's cause and development. The hypothesis (or hypotheses) would be based upon:

- Observations made at the scene (fire patterns, fire dynamics, results of any technical investigations)
- Remaining physical evidence (viable ignition source(s) etc.)
- Other information obtained from people and technical systems

Developing good hypotheses initially involves divergent thinking to ensure that all relevant

and possible option are considered. Convergent thinking is then used to organise the results and ensure that redundant and irrational hypotheses are eliminated.

12.2 Testing the hypothesis (or hypotheses)

The aim of hypothesis testing is to elaborate possible fire cause hypotheses for the final evaluation process. Either a hypothesis is set up by the customer or is a result of the most probable fire cause, assuming equal probabilities to all possible fire causes. The investigator uses his or her knowledge and skills to challenge or test a potential hypothesis in a scientific manner. The hypothesis being considered should be compared with all other known facts. Two important points to consider at this stage are:

- Is the hypothesis testable? (i.e. can evidence be found to actually test the validity of the statement?)
- Or is the hypothesis falsifiable, (i.e. can evidence be found to show that it is not true?)

A hypothesis can be tested *physically* by conducting experiments, *analytically* by applying accepted scientific principles or by referring to *scientific research*. The experiments can be done in situ (see below for details) and in certified test areas/laboratories. Whenever the investigator relies upon research as a means of hypothesis testing, references to the research must be acknowledged and cited.

The testing process needs to be continued until all reasonable hypotheses have been tested, and one is determined to be most/more consistent with the evidence and with the principles of science.

Any hypothesis formulated for causal factors (e.g., first fuel, ignition source, and ignition sequence), must be based on the analysis of facts. Those facts are derived from evidence, observations, reliable witnesses information (calculations), experiments, and the laws of science. Speculative information must not be included in the analyses. Below are some example questions to consider:

- Is there one point of origin or several? Has the fire started at position A or position B or at both position A and B?
- Is the hypothesised ignition source viable for the first fuel ignited?
- Is the required time for ignition consistent with the time line associated with the cause hypothesis and known facts of the incident?
- What were the circumstances that brought the ignition source in contact with the first fuel to catch fire?
- What, if any, were the faults required for ignition to occur?
- Are the signs left by the fire what you would have expected given information provided to you and given your own hypotheses? For example, would the item of furniture have protected the floor or the wall? Does the fire damage suggest that the furniture in question has burned from one specific direction?

12.3 Final hypothesis

The forensic scientist has to do the evaluation process by evaluating all findings under the most probable or the presented propositions (fire causes). The evaluation consists in estimation of a probability to get the findings under one or the other cause of fire. Finally, the scientist has to state the conclusion as a relation of these probabilities, normally in a predefined statement of a verbal scale.

A personal opinion of a statement of a probability of a cause of fire is possible under the conditions of first doing the evaluation as mentioned above and second transparently stating all assumptions and information included resp. not included in the process of decision making. It may be misleading if this process is not transparent and the case related information limited.

12.4 Conclusion

The point of origin/seal of fire can be described as the interpretation of the damage done

by the fire. One of the tools used in the investigation of a point of origin is the ability to recognise, interpret, identify and analyse these fire patterns. When investigating the fire patterns, you must be aware of those which could have been made by the possible offender. When investigating cases of suspected arson, it is sometimes possible to find patterns left by the offender in the point of origin and also establish their activities in or around the scene of the fire.

Note that, in post-flashover fires many of these patterns may not survive. After the reconstruction, check the following things in the area where a witness says the fire started:

- Do the details given by the witness lay within the range of possibilities assuming hypothesis 1 with your own observations and hypotheses?
- What is the damage like? Is it clearly outside of the possible variability assuming hypothesis 2 the fire started there and didn't spread there from elsewhere?
- Would it be expected clearly other damage pattern? Can the fire have spread to this place? If so, at what stage of the fire?
- Would it be expected that the fire spread accordingly with the discovery of the fire?
- What possible objects of origin (i.e. electrical appliances) are present in the area?
- Have they been in use? Were they plugged in?
- Does the fire damage lay within the range of possibilities or can they be eliminated?

If your opinions differ from those given by a witness, it is very important that the investigation records that this area has been properly investigated, that all possible objects of origin have been examined, that they can be eliminated, and why. This must ultimately be mentioned in the report.

13 PRESENTATION OF RESULTS

The way in which a report is written can vary from country to country. The list (table 1) below is recommended for use as a checklist for what a report should contain. The senior management and quality management departments for each institute are responsible for ensuring that a protocol for peer reviewing the fire investigation process and subsequent report is written and followed.

Table 1 Report structure

Introduction and basic information	Date and time Place Purpose of the investigation The condition of the scene when the fire investigation was carried out The fire investigator/specialist responsible
Working methods	Investigation by scientific methods Excavation Hypothesis testing
Background information	Information relevant to assessing the fire scene: <ul style="list-style-type: none"> • From people • From technical systems
Fire investigation at the scene (technical)	Limitations Descriptions of objects Descriptions of investigation results: <ul style="list-style-type: none"> • Outside and inside together with windows and other openings • Injured people and/or fatalities • List of contexts/evidence from the scene and the results of any tests carried out in situ
Assessment and conclusion	Conclusions from hypothesis testing regarding: <ul style="list-style-type: none"> • The area/ point of origin • The cause of the fire
Definitions and references (as appropriate)	Definitions of the most common and important terms used in fire investigation. References to validated literature Building plans/drawings

14 HEALTH AND SAFETY

Preparation is key before attending any fire scene. At the very least, you must have the following basic equipment:

- Protective clothing (see Appendix 4)
- Video recording equipment and a camera
- Other equipment (tools, cordon tape, markers, pens, sampling containers/bags etc.)

It is advised that you prepare your own checklist of personal protective equipment (PPE) and other equipment so that you are fully prepared before attending a scene.

In addition to any other risk or safety assessments already in place, fire investigators must undertake their own risk and safety assessments at the scene both outside and inside¹², and must be aware that they are responsible for their own safety and those who are present with them. If necessary, specialist advice may be required.

Be aware that some risks, e.g. decreased integrity of the building construction, can occur long after the fire was extinguished.

During attendance, the risk assessment should be updated regularly, as required.

Be aware of working conditions at all times and consider the own risk and safety assessments made to decide to work at the fire scene.

An investigation may have to be delayed until it is deemed that the structure is safe 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.

Any hazard or risk assessment must be dynamic and reassessed after any alteration or modification of the structure. It is recommended that fire scene investigations are not carried out alone for improved safety. In this phase of an incident, fire investigators must assess the actions of the first responders with respect to the security of the scene.

Strict surveillance and security measures must be put in place and maintained to protect the integrity of the scene before, during and, if appropriate, after the fire investigation.

14.1 Secure the Scene

In order to ensure integrity of the scene, make sure that a sufficiently large area is cordoned off. Ensure that as few people as possible have access to the area inside the cordon. Consider using an inner and outer cordon, if that works best. Ensure that the outer cordon is sufficiently large as to encompass all areas containing possible evidence.

14.2 Safety and Working Conditions

Obtain the existing hazard and risk assessment from the responder, if one was undertaken.

The fire investigator must undertake their own risk assessment at the scene, and must be aware that they are responsible for their own safety as well as the safety of those around them. The outside area must be assessed for risks and hazards. These include (but are not limited to) structural safety of the building (mechanical, electrical, roof, walls, the presence of sharps such as glass or other debris etc). If necessary, specialist advice must be sought.

An investigation may have to be delayed until it is deemed that the structure is safe 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. If a petrol/diesel-driven electricity generator is used, in order to minimise potential contamination, do not refill the generator with fuel at the scene, be careful where the generator is placed and always

¹² Last Minute Risk Assessment methodology - LMRA

use disposable gloves (which **MUST** be left outside the scene).

Any hazard or risk assessment should be dynamic and repeated after any alteration or modification of the structure.

Other information about the contents and possible hazards within the scene must also be noted (e.g. electrical, gases, asbestos, chemical hazards, other hazardous contents, including aerosols, and the potential danger of secondary explosions).

This information needs to be communicated to all personnel on site and to the specialist upon their arrival.

14.3 Scene Security

Cordoning off with tape alone is not an efficient way to preserve a scene. It may be enough to keep the general public away, but it will not stop or prevent entry. For this to be effective a human presence at the cordon (police officer or fire fighter) is vital. This presence must ideally be maintained at the scene until the fire investigation is complete; however, if this is not possible, the absence of a 'scene guard' must be recorded.

Ideally, the person maintaining the cordon should start a scene log, recording the time of entry and exit of all persons to and from the scene. Information must include the identity and contact details of all individuals entering the scene, and may also include details of personal protective equipment (PPE). Be aware that you may need to record your own times of arrival and departure for reasons of health and safety and/or to establish a time line of events.

Bear in mind that the property owner or workers at the incident may later become suspects and their entry to and from the scene must also be closely monitored.

14.4 Path of Entry

The route of any common approach path will vary depending on the type of incident, however the same method must be used to decide a route, before clearing and marking the path.

Any items that could be potential evidence must be photographed and noted in situ and removed or protected so as to clear the approach path to the area of interest (i.e. the fire damaged area).

This path must be clearly marked and used by all personnel to enter and exit that area.

With any fatal/serious injury fire or suspected arson fire, the common approach path must not be along the normal approach to the area of interest/seat of the fire. Be aware that a perpetrator may have used such a path to enter or leave the scene.

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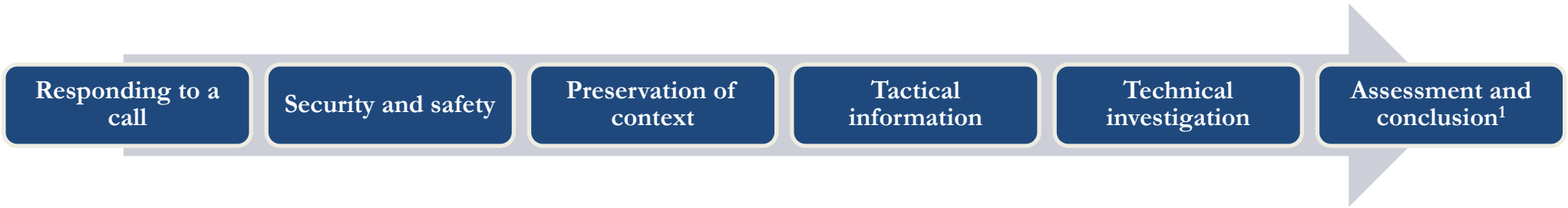
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16 CHANGES FROM THE PREVIOUS VERSION

Not applicable (first version).

APPENDIX 1 INVESTIGATION PHASES



<p>En route – record At the scene – document General information for documentation Plan for preservation Communication and coordination</p>	<p>Secure the scene Safety and working conditions Adjustment of security Path of entry</p>	<p>Dialogue (exchanging all relevant info) Recording in situ i.e.: 360 ° photo Drones Alternate light source Sampling, i.e.: Liquids Bottles and cans Technical systems Fatalities Documents</p>	<p>Background information from: People Technical systems</p>	<p>Interpretation of available information Investigation strategy First general overview Limits of the investigation Excavation</p>	<p>Hypothesis Develop Test Conclude Determination: Interpretation of the fire pattern Synchronization -with background information Documentation of reconstruction Conclusion: Point of origin Cause of fire</p>
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	Involved
	Could be involved
	Not involved

APPENDIX 2 TACTICAL INFORMATION

	Property owner/ First person at the scene/Witness/Neighbours ¹³
The property	<p>Are there any particular hazards present within the premises (for example asbestos, building components, animals)?</p> <p>Ask for photographs and/or videos which show what the property looked like inside and outside prior to the fire.</p> <p>Ask the occupier/representative, to sketch a plan of the rooms/furniture and of the building.</p> <p>Was the property secure before the fire?</p> <p>Was there any CCTV (surveillance cameras) in the area or on other buildings?</p> <p>Were the premises and/or contents insured? If yes, when was the policy renewed?</p> <p>Were there any electrical appliances, heating appliances or any other potential sources of ignition in the area?</p> <p>Were there any fire/smoke alarms in the premises? If yes, where were they located and did they operate?</p> <p>Were there any ignitable materials or liquids, or materials, liable to spontaneous combustion, present?</p> <p>What was in the area where the fire was first observed?</p> <p>Who has access and/or keys to the property?</p> <p>Who has knowledge of the code/PIN for any security systems?</p> <p>Are there any photographs or films of the fire, or of the property before the fire?</p>
Actions and people before the fire	<p>Did any windows break before the fire brigade arrived? If so, when and in what order?</p> <p>Had any candles been used?</p> <p>Has any repair work, alterations, welding or any type of “hot work” been undertaken in the area? If yes, obtain details.</p> <p>Has anyone smoked in the area of origin, and if so, when was the last time this occurred?</p> <p>Have any unusual activities been noticed in the surrounding area?</p> <p>Have there been any previous fires at this address?</p> <p>Have there been any previous problems with any appliances?</p> <p>Have there been any previous problems with the building services/fixed installations (electricity, gas and water supplies)?</p> <p>If there was an intruder alarm, was it armed prior to the fire?</p> <p>Were any unusual sounds heard before the fire?</p> <p>Were the doors and windows closed when they left the area?</p> <p>Were there any strange smells?</p> <p>What were the actions of the last person in the property?</p> <p>When did that person leave the property?</p> <p>When did they discover the fire?</p> <p>Where were the occupants of the building when the fire broke out? What were they doing?</p> <p>Where were they when they discovered the fire? What was the available lighting?</p> <p>Which doors or windows were open when the fire was discovered?</p> <p>Who discovered the fire? What did they see?</p> <p>Had any windows broken before the fire was discovered?</p>
The fire	<p>How and why was the fire detected? Was it by the smoke, flames or heat?</p> <p>How did the fire develop?</p> <p>How did they escape from the building?</p> <p>How high were the flames?</p> <p>How intense was it?</p> <p>How long did it take from the discovery of the fire until the alarm was raised?</p> <p>How much smoke was given off?</p> <p>Was any attempt made to extinguish the fire?</p> <p>Was the fire at high or low level? What colour were the smoke and flames?</p>

¹³ The listed questions are just examples. Other relevant questions may be asked depending on the specific fire investigation.

APPENDIX 3 EXAMPLES OF FIRE CAUSES

In every case, regardless of how the motive / background to the fire is categorised (arson, accidental, sickness, poor judgement etc.), a general interpretation of the fire damage must be made, in order to determine the cause. Ignition may be defined as that process by which a rapid exothermic reaction is initiated, which then propagates and causes the material involved to undergo change, producing temperatures greatly in excess of ambient. Below is a short list of examples and it is to be duly noted that the list is not complete:

Auto-ignition	A substance spontaneously ignites in normal atmosphere without an external source of ignition: <ul style="list-style-type: none"> • Biological (i.e. hay) • Chemical (i.e. pyrophoric substances)
Electrical	Heat conduction/convection from: <ul style="list-style-type: none"> • Electrical equipment and appliances (i.e. shortcuts, bad connections, overload or insulation faults on wiring) • Lighting equipment and heaters (i.e. overheated)
Embers	Ember is glowing hot and radiate a substantial amount of heat: <ul style="list-style-type: none"> • Ashes (i.e. from a conventional fireplace) • Sparks (i.e. airborne embers from a bonfire) • Glowing fire debris • Live charcoal (from i.e. a BBQ) • Lit cigarette
Explosion	An explosion releases an extreme amount of energy, usually with the generation of high temperature: <ul style="list-style-type: none"> • Natural (i.e. volcanic processes) • Chemical (i.e. explosives, gases) • Electrical and magnetic (i.e. high energy electrical arc which rapidly vaporizes metal and insulation material) • Mechanical and vapour (i.e. BLEVE¹⁴)
Friction	The force resisting the relative motion of solid surfaces, fluid layers and material elements sliding against each other (i. e. faulty wheel bearings or brakes).
Natural phenomenon	A natural phenomenon is an observable event which is not man-made: <ul style="list-style-type: none"> • Biological (i.e. fermentation of sugar into acids, gases and/or alcohol¹⁵) • Chemical (i.e fire from a rapid oxidation) • Geological (i.e. volcanic activities) • Meteorological (i.e. lightning)
Open flame	An open flame can come from for an example a <i>lit</i> . <ul style="list-style-type: none"> • Lighter • Matches • Candle

¹⁴ Boiling Liquid Expanding Vapour Explosion

¹⁵ Could also be an accelerator

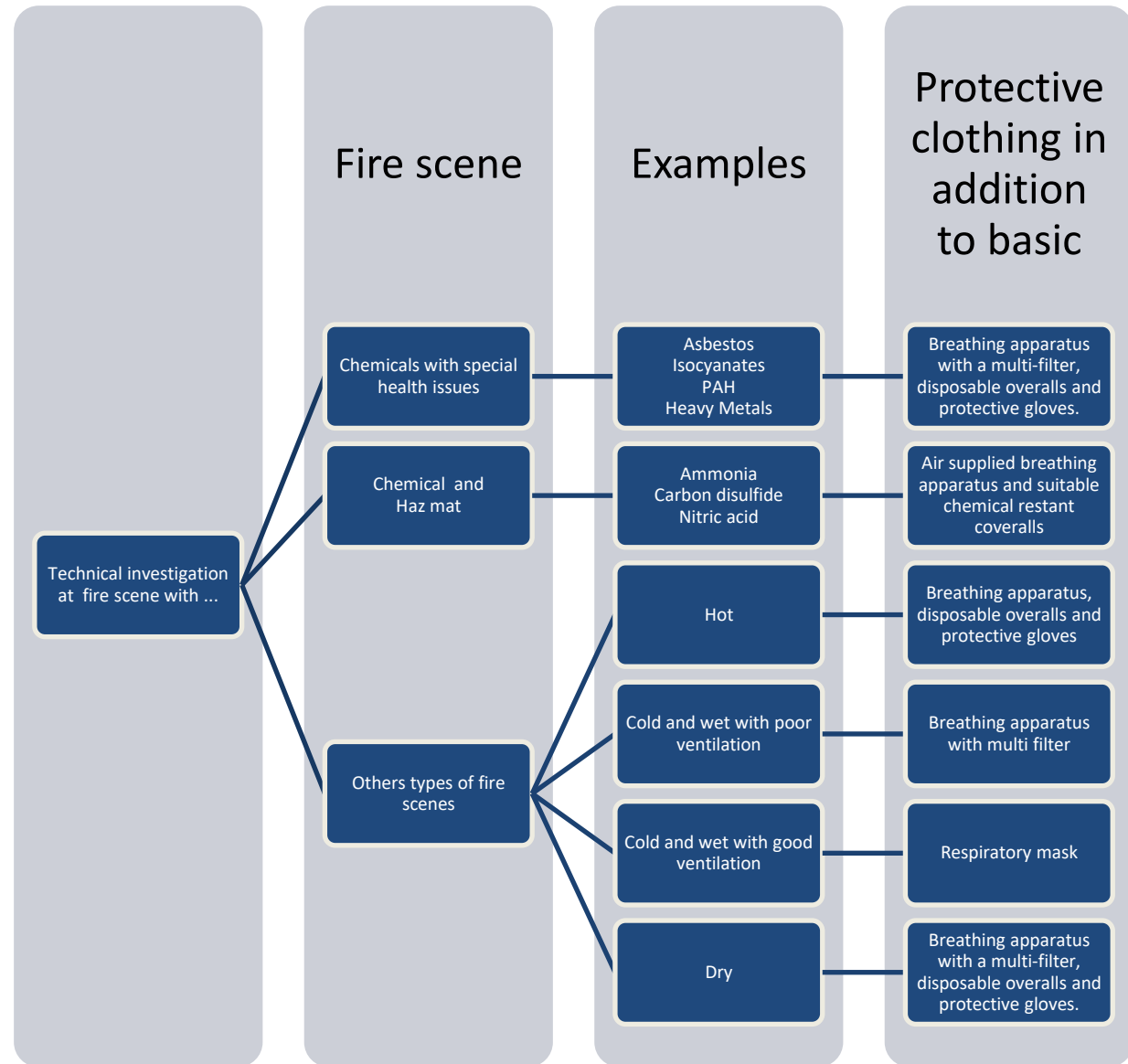
APPENDIX 4 PROTECTIVE CLOTHING

Add your basic protective clothing with the recommended protective equipment (right column).

Follow the path in the figure to find the fire scene that is representative to yours.

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 5 DEFINITIONS

The following list of definitions is not complete, more can be found in i.e. *Dictionary of Forensic Science, Oxford*¹⁶

Accelerant	The flammable material that is used in an arson to accelerate the fire process. An accelerant can be a solid (i.e. paper, PUR), liquid (i.e. petrol) or gas (i.e. propane).
Arson	The act of deliberately setting a fire with criminal intent.
Auto ignition (Spontaneous)	A substance spontaneously ignites in normal atmosphere without an external source of ignition: <ul style="list-style-type: none"> • Biological (i.e. hay) • Chemical (i.e. pyrophoric substances)
Chimney effect	The movement of a rising stream of heat, smoke and gases through a shaft or similar vertical space (for example, stairways) or corners.
Combustion	The chemical reaction broadly defined as burning which occurs when a fuel and an oxidant is combined at elevated temperatures. Heat is important, both as a product of the reaction and to ensure that the reaction has enough energy to be self-sustaining.
Complete combustion	All organic material is burnt away and consumed in the combustion process. This includes inorganic materials that are flammable and involved in the fire.
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).
Daubert standard	Three critical United States Supreme court cases that have contributed to the precedents regarding the admissibility of scientific evidence and testimony in that country. First decision: It was the role of the judge to determine if scientific evidence is relevant and reliable. The two other decisions contributed to the expansion of expert witnesses to apply Daubert standards to all expert testimony, not just strictly scientific expert testimony.
Deflagration	Strictly defined, a region of combustion or flame front that is moving at subsonic speeds. Informally, rapid burning is often referred to as deflagration.
Detonation	A chemical reaction of explosive materials that spreads at supersonic speed 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.
Fire	A self-sustaining 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 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.

¹⁶ By Suzanne Bell, ISBN: 978-0-19-959400-9

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 liquid releases combustible vapour.
Fusing point (or 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.
In situ	On site or on the premises
Incendiary device	Devices that are used to ignite an accelerant in an arson fire. They can range from simple to sophisticated.
Incomplete combustion	A combustion process in which not all flammable materials are burnt completely (CO and soot is formed).
Inert gas	A non-flammable gas that is used, for example, as a means of extinguishing fire. Inert gas works by "reducing the oxygen content in the protected room from the normal 20.9% to 11.2% and thus extinguishing more or less all types of fire. Inert gas is used in automatic extinguishing systems and for protecting enclosed areas, for example computer rooms and ship tanks. Can also be used for welding, for example carbon dioxide (CO ₂) or argon.
Non-Combustible 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 odourless, colourless gaseous element. It is non-flammable but fuels a fire. (O ₂ – ordinary air contains approximately 21% O ₂).
Point of Origin	The place at which the fire started.
Pyrolysis	Chemical degradation of a material due to thermal stress.
Radiation	The transfer of heat by means of electromagnetic waves (infrared light, transmitted in straight lines at the speed of light).
Slow burning	Burning speed is between 1 and 10 mm a second.
Smoke	Small solid particles in gas, caused by combustion or pyrolysis.
Smouldering	A slow burning process without flames (characterised by an increase in temperature and smoke, but no light).
Stratigraphic excavation	Stratigraphy is a key concept to modern archaeological theory and practice. Modern excavation techniques are based on stratigraphic principles as applied in fire investigations: Original horizontality Lateral continuity
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.

APPENDIX A3 – EXPLOSION INVESTIGATIONS

This Guide has been worked out for all people in Europe, including fire investigators and forensic experts, who may be involved in the Investigation of Explosions. This work represents a harmonisation of current knowledge and material available.

The Guide is the result of a perpetual cooperation of experts on this field and would not have been possible without the participation of various personnel from the following institutions:

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Responsible for revision 2019 and of original document:

Eva Ljungkvist, NKC Danish National Police eb1006@politi.dk

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1 AIMS

This practical guide aims to provide a framework for explosion investigations. It offers recommendations for how to conduct an investigation at the scene of an explosion, in order to achieve the best possible results. A First responder/investigator/specialist investigating a scene is someone who is involved in determining the origin, cause and development of an explosion. This work brings together current available knowledge and material and is the result of an extensive study of current practice used by forensic science laboratories and institutes throughout Europe.

The term 'practical guide' does not imply that the practices laid out in this manual are the only acceptable methods used in fire scene investigation.

2 SCOPE

Whilst this Guide contains information concerning all types of explosions, the scene examination stage focuses mainly on dispersed phase explosions. Dispersed phase explosions are defined as those involving a mixture of gas, flammable liquid vapours or dust with air.

This Guide is designed for the First Responder (Fire Brigade Officers, Police Officers), the Investigator (Crime Scene Investigator, Fire Brigade Officers) and the Specialist (Forensic Scientist).

The success of any scene investigation can depend on the input of the persons initially involved. Therefore, the actions of the First Responders can have an important impact on the outcome of the case. Mistakes that are made in the first phase can often not be repaired later.

3 DEFINITIONS AND TERMS

In the process of the investigation, an open-minded approach should be adopted with all the possibilities being considered. Mixtures of flammable gases, vapours, mists and dusts with air or oxygen can be ignited by sources such as:

- Flames,
- Mechanically generated sparks,
- Electrical sparks,
- Sparks by electrostatic discharging,
- Hot surfaces.

However, glowing tobacco generally does not ignite mixtures of flammable gases or vapours of flammable liquids like hydrocarbons such as propane or petrol.

Only some gases and vapours in mixture with air can be ignited by glowing tobacco: see Appendix 1.

The effects of explosions can damage the neighbourhood by both *overpressure* and *heat transfer*. Apart from these *direct* effects, explosions can produce fragments and rubble that can produce *indirect* effects when they impact with other objects.

The centre of the explosion can often be found by consideration of the directional indicators.

Dispersed phase explosions are characterized by the absence of a defined seat of explosion and by the presence of widespread effects on glass, windows, doors, ceilings, roofs, walls etc.

By contrast *condensed phase explosions* are characterized by well-defined localized

damage, evidence of high velocity penetration and shattering of materials.

Physical explosions usually result from the sudden bursting of a pressurised container by failure or/and overpressure. Physical explosions can occasionally cause severe damage similar to explosions caused by blasting explosives if they result from a sudden phase transition, usually the spontaneous evaporation of an overheated liquid. This subtype of physical explosion is commonly named BLEVE (boiling liquid expanding vapour explosion).

A BLEVE can occur with or without an additional chemical reaction. The most common example for a BLEVE without any chemical reaction (“cold BLEVE”) is the bursting of a thermal storage water heater because of overheating. The mechanism of propagation in this subtype is based on an unstable two-phase system and can be explained by „resonance of bubbles “.

When in contrast liquified flammable gases are affected by this phenomenon, as for example overheated LPG in cylinders, the emerging explosive atmosphere can additionally cause a subsequent dispersed phase explosion with particularly severe damage, mostly with a fireball (“hot BLEVE”).

Appendix 2 Definitions gives more information.

4 RESOURCES

4.1 Personnel

Explosion incidents require a special knowledge and therefore only a Forensic Scientist, or equivalent, should lead these types of investigations. In many instances he/she will be assisted by the second responder. Even then, other specialized technical people i. e. gas engineers may need to be consulted. It is recognized that different countries will have various levels of expertise with regard to their scene examiners whether they are Scene of Crimes Officers (SOCOs), Crime Scene Investigators (CSIs) or Fire Brigade Officers.

The First responder, the investigator(s) and specialist(s) must verify that they have demonstrable competencies and experience that are relevant to the task at hand. A conclusion will qualify as scientific findings if it can be demonstrated that it is the product of a sound scientific method. The ‘scientific method’ is the process of formulating hypotheses, and then conducting experiments/analyses to provide support for, or against, the hypothesis that is considered relevant at the time. This may lead to the formulation of further hypotheses, as the process is repeated.

The first responder, investigator and the specialist are qualified as an expert by knowledge, skill, experience, training and education and may give evidence in the form of an opinion, or otherwise if:

- The expert’s scientific, technical, or other specialised knowledge will help the court to understand the evidence or to determine a disputed fact.
- Their testimony is based on sufficient facts or data.
- Their testimony is the product of reliable principles and methods.
- The expert has reliably applied the principles and methods to the facts of the case.

With regard to the above, the main role of the investigator/specialist will be to continue and if necessary enhance the measures for the preservation of evidence taken by the first responder.

Additionally, the investigator may depend on his level of expertise:

- Collect more detailed information about the scene and the circumstances of the incident. For explosions in the occupational field important special attention is invited to
 - The explosion protection document with classification of zones according annex i of 1999/92/etc.
 - Manual logs
 - Data stored in the process control system
- Provide a comprehensive picture documentation of the scene

4.2 Equipment

See Appendix A2 -section 5 – Methods.

4.3 Reference Materials

See section 11 - References.

4.4 Facilities and Environmental Conditions

See Appendix A2 -section 5 - Methods and section 14 - Health and Safety.

4.5 Materials and Reagents

Not applicable.

4.6 Allocation of Responsibilities and collegiate approach

See Appendix A2 section 4 – Resources

5 METHODS

5.1 Gathering of information

List all eye witnesses and injured persons. Question them as appropriate and record their answers. Make notes of your own observations and seek information about the circumstances before explosion, such as:

- photograph the onlookers and surrounding area
- weather condition
- building construction
- contents of premises, presence of natural gas, LPG or storage of flammable liquids etc.
- changes of circumstances in technical process shortly before explosion

5.2 Liaison

On arrival, liaise with the first or/and second responder. Collate information to establish the situation, identify existing hazards and ensure that the scene continues to be properly preserved. Establish contact with the Police Officer in charge.

The most important aspects are:

- Initial Assessment, e. g.
 - Plan of approach
 - Hazards
 - DNA
 - Resource implication
 - Manpower
 - Specialists
 - Equipment
- Scene Recording
 - Photography
 - Video
 - Mapping

- Scene Notes
- Full assessment of accessible areas as far as possible
- Structural damage and features characteristic of type of explosion
- Suitable equipment (clothes, footwear; tools, gloves) free of contamination

The first responder will liaise and provide assistance to the Investigator / specialist as appropriate.

5.3 Scene Examination

Review all possible hazards and continue throughout the investigation and assess the information of the entire scene and determine the outer perimeter. The investigation can either be made from the perimeter towards the centre or vice versa. This decision should be made by the investigator.

Collect information from all sources (e. g. CCTV video recordings, fire and intrusion detection systems). Consider the scene in more detail, e. g. dimensions, directional indicators, burning patterns and establish the type of explosion (e. g. gas or flammable liquid vapours/air mixtures, condensed phase explosions, physical explosions, BLEVE). Eliminate various types of explosion as far as it is possible.

Following an initial assessment of the scene devise a programme of how the investigation will be conducted and if needed, involve and consult specialists, such as: gas engineers, specialists for heating systems etc. Communicate with witnesses at the scene and be aware that other information may be available in the future. Ensure that witness accounts are recorded and where appropriate documented by statements according to legal protocol. Document all observations (notes, plans, photographs and video recording).

If appropriate, it is preferable to test the system in situ to determine what items are relevant and collect samples for analysis and testing, and appropriate control samples if necessary. Excavate debris in the area of interest; take further samples as appropriate and sequentially record such actions.

Consider reconstructions, take measurements and if possible establish further information about the incident and assess the investigation and formulate the preliminary conclusion. Request that the scene is preserved for further investigations. Establish the sequence of the events according to the evidence as far as possible

6 VALIDATION AND ESTIMATION OF UNCERTAINTY OF MEASUREMENT

Methods should be documented and factors that must be considered in the study:

- sampling and its precision
- bias, margin of error
- field of work (detection / sensitivity), and suitability (in terms of environmental conditions)
- competence development of staff

Where relevant, reference should be made to key sources of uncertainty, as well as reporting uncertainty. That could be for an example following:

Dispersed phase explosions (gas, vapour, mist, dust or mixtures of these)

- Analyse samples as appropriate to identify
 - The gas,
 - The flammable liquid,
 - The dust
- Examine items recovered from the scene such as:

- Pipes,
- Hoses,
- Cylinders,
- Regulators,
- Valves,
- Electrical devices,
- Clothing, shoes
- If necessary carry out tests to gain additional information such as:
 - Flash point of the flammable liquid
 - Distribution of the particle size of the dust
 - Electrical conductivity
 - Mechanical overheating
 - Ignition source energy
 - Ignition source temperature

Physical explosions

- Examine the pressure vessel and associated fittings such as: armatures, regulators, valves
- Establish the specifications of the vessel
- Consider metallurgical examination
- Evaluate the heating process involved

Research further information:

- About the properties of the material in question
- Proper handling of material
- Similar cases relating to the material

Experimentation:

- Development and empirical testing of hypotheses
- Perform relevant calculations and if adequate computer simulations

Circumstances of the incident:

- Deviation of normal procedures (“What has changed?”)
- Human factors
- Environmental factors

7 QUALITY ASSURANCE

First responders, investigators and specialists are advised to take part in relevant collaborative exercises and/or proficiency tests periodically, so that their competence can be demonstrated.

8 HANDLING ITEMS

The general recommendation is to preserve the scene, and thereby, the evidence. In other situations, the advice may concern the correct actions to take when deciding to remove or preserve potential evidence. If any items are moved from their original positions, this must be contemporaneously recorded. Establish a scene-log to record people entering the scene. Prevent any unnecessary further damage and contamination of the scene as much as possible and refrain from disturbing any materials or appliances (e. g. switches, valves).

Leave deceased in situ.

Prevent deterioration of evidential material by wind, rain, walking on the area (visible evidence like building debris, glass splinters and latent traces such as explosives

residues). Protect obvious evidential material with tents or awnings. Record the essential removal of items in cooperation with second responder and the Investigator.

9 INITIAL ASSESSMENT AND DOCUMENTATION

See Appendix A2 section 9 – 13.

10 HEALTH AND SAFETY

Prevent unnecessary entry of people (cordon off the scene if possible). Evaluate the scene for safety hazards:

- Give first-aid assistance within your capability and prevent further injuries.
- Look at the construction and, in particular, overhead potential hazards such as masonry, roof tiles, staircases, chimneys, walls, floors, and window glass.

Identify potential hazards:

- Call in relevant bodies as appropriate, such as: bomb squad, building surveyors, structural engineers, officials from the gas, electricity and water companies.
- Ensure that electricity and gas supplies are switched off - possibly ventilate rooms.
- Consider other hazards like:
 - Introducing ignition sources (sparks, electrical equipment, inappropriate tools)
 - Chemical hazards
 - Biological hazards
 - Radioactive substances
 - Asbestos
 - Risk of secondary explosion owing to the escape of flammable gases from lpg-cylinders or tanks or leakage of combustible liquids (petrol, thinners etc.) Or burst (physical explosion) of gas cylinders because of overheating by a following fire
 - Unexploded incendiary devices
 - Improvised explosive devices (ied) or traps

11 REFERENCES

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12 AMENDMENTS AGAINST PREVIOUS VERSION

Not applicable (first version).

APPENDIX 1 TERMS

Buoyancy can play an important role during the mixing of different gases or vapours. Generally, gases or vapours that are heavier than air (density ratio >1) tend to fall and similarly gases or vapours that are lighter than air (density ratio <1) tend to rise.

This is only valid as long as there are different regions with different mixing ratio (inhomogeneous mixture), because buoyancy depends on the density ratio of the neighbouring regions and not on the molar mass of the mixing components. A homogenous mixture does not measurably unmix by gravity within the typical dimensions of buildings.

The Boiling Point is the temperature at which the equilibrium vapour pressure of a liquid equals the atmospheric pressure. Mixtures of flammable liquids have a boiling range.

The ratio of evaporation is a practical indication of how quickly a liquid evaporates, in relation to Diethyl ether (defined as 1), when exposed to the atmosphere. The lower the value is, the more volatile the liquid. Mixtures of flammable liquids have a variable ratio of evaporation. The evaporation ratio of petrol may vary (addition of Butane in winter). The actual evaporation rate can substantially depend on the distribution of the evaporating liquid (specific surface to mass ratio, wick effects on the matrix).

The flashpoint is the minimum temperature to which a material or a product must be heated for the vapours emitted to ignite momentarily in the presence of flame under specified conditions.

The obtained values can depend substantially on the testing conditions (i.e. "open cup" or "closed cup"). For the estimation of explosion risks closed cup methods (e.g. ISO 2719, ISO 13736) are preferably.

The explosive limits dependence of vapour pressure and temperature. The lower explosive limit is less than the flashpoint, so explosions can occur at temperatures below the flashpoint!

Generally closed cup methods (ISO 2719, ISO 13736) are used for a rough estimation of the lower explosion point. Furthermore, the explosion point of halogenated solvents cannot be estimated by the flashpoint at all. Explosive limits give the proportion of combustible vapour in a mixture, between which limits the mixture is ignitable.

The lower explosive limit is the lowest concentration of vapour in air, which will explode upon contact with a source of ignition. Below the lower explosive limit, the mixture is too lean.

The upper explosive limit is the highest concentration of vapour in air, which will explode upon contact with a source of ignition. Above the upper explosive limit, the mixture is too rich to burn.

The minimum ignition source energy is the relevant data for ignition of explosive mixtures when exposed to sparks - the data show clearly, that most of the sparks (electrical and often non-electrical) occurring in practice dissipate higher energies.

The auto-ignition temperature is the lowest temperature at which a combustible material ignites in air, without an external ignition source such as spark or flame. The auto-ignition temperature is particularly sensitive to testing conditions. A commonly used measurement setup is specified in EN 14522. The actual temperatures, at which items ignite in practice may strongly depend on circumstances. Ignition by hot surfaces often occurs at substantially higher temperatures than given in the table, especially if the exposition time is rather short.

Formation of explosive dispersed phases can be governed by:

- Diffusion
- Gravitation
- Thermal convection
- Turbulence.

Additional parameters include

- Relative density,
- Thermal input and output within the system.

There is a large number of different types of ignition sources (see Section 5 in EN 1127-1:2011).

Ignition sources of special practical relevance are

- Flames,
- Mechanically or electrically generated sparks,
- Sparks by electrostatic discharging,
- Hot surfaces.

The ease of ignition of a substance can depend on the type of ignition sources. Hydrogen for example needs comparatively low ignition source energies for spark-ignition but comparatively high temperatures for auto-ignition. Only a small number of substances are known to be ignited by smouldering tobacco: carbon disulfide, hydrogen, acetylene, ethylene oxide, hydrogen phosphide, hydrogen sulfide and diethyl ether. Flammable hydrocarbons such as propane or petrol are not ignited by smouldering tobacco.

The effects of explosions can damage the neighbourhood by both pressure and heat transferred.

The theoretical maximum impact of a deflagration occurs when there is a homogeneous and stoichiometric mixture. This would be rare in practice. Whilst the volume of the explosive atmosphere can be relatively small compared to the total volume the damage can be widespread.

The centre of explosion can be determined by directional indicators. The given maximum pressure data does only apply for deflagration. In seldom cases there can be a transition to detonation resulting in substantially higher pressures. The observed effects therefore can be useful to give an indication if there has been a detonation or a deflagration.

Prediction of maximum pressures in the case of detonations, pressure piling between connected volumes and propagation in pipes (towards dead ends) is quite difficult. Numerical calculations can be misleading because there are many unknown parameters.

The effect of heat transfer increases with the heat flux density and the duration of exposure.

A Boiling Liquid Expanding Vapour Explosion (BLEVE) can only happen when a particular sequence of events occurs. The liquid can be either flammable or non-flammable.

- Rapid vaporisation of the liquid by overheating.
- The container bearing the liquid (gas cylinder, transportation tanker etc.) ruptures.
- A fireball can be created by the ignition of the mixture of the vapour and air.

Traffic collisions involving the transportation of flammable liquids have resulted in BLEVEs. Typical heat flux densities of BLEVE fireballs are 200 up to 350 kW/m².

Both flammable and non-flammable liquids are capable of creating another type of BLEVE. The theory of 'bubble resonance explosion' offers an explanation for this type of explosion. This theory involves the production and the synchronous collapse of very small bubbles. It is documented that the collapse of bubbles of 1 μm diameter can give rise to an overpressure of about 15 kbar.

APPENDIX 2 DEFINITIONS

BLEVE:	Acronym for “Boiling Liquid Expanding Vapour Explosion”, explosion of containers filled with liquids after overheating/-s.
Combustion:	ISO: Exothermic chemical reaction of a fuel substance with an oxidizing agent (usually the oxygen portion in the ambient air)
Deflagration:	Rapid combustion in which the velocity of the reaction is less than the speed of sound ISO: Combustion wave propagating at subsonic velocity.
Detonation:	Very rapid combustion in which the velocity of the reaction is equal to or greater than the speed of sound. ISO: Reaction characterized by a shock wave propagating at a velocity greater than the local speed of sound in the unreacted material
Explosion:	Sudden conversion of potential energy into kinetic energy producing an overpressure wave. ISO: <chemical> Abrupt expansion of gas which may result from a rapid oxidation or decomposition reaction, with or without an increase in temperature
Explosive Limits:	The amounts of vapour in the air that form explosive mixtures. If the percentage of flammable material in the air is between the minimum and maximum limits, the presence of a flame or a source of ignition is likely to lead to rapid combustion or explosion
Lower Explosive Limit (LEL):	Minimum concentration of a gas or a vapour in air below which flame propagation does not occur in presence of an ignition source (arc, flame, heat).
Upper Explosive Limit (UEL):	Maximum concentration of a gas or a vapour in air above which flame propagation does not occur in presence of an ignition source (arc, flame, heat).
Explosive atmosphere:	Mixture with air, under atmospheric conditions, of flammable substances in the form of gases, vapours, mists, aerosols or dusts in which, after ignition has occurred, combustion spreads to the entire unburned mixture (atmospheric conditions: temperatures between -20 °C and 60 °C and pressures between 0,8 bar and 1,1 bar)
Flame:	Rapid self-sustaining sub-sonic propagation of combustion in a gaseous medium, usually with emission of light (EN ISO 13943: 2010)
Flashpoint:	Minimum temperature to which it is necessary to heat a material or a product for the vapours emitted to ignite momentarily in the presence of a flame under specific conditions.
Hazardous place:	A place in which an explosive atmosphere may occur in such quantities as to require special precautions to protect the health and safety of the workers Which quantities of mixture are hazardous depends on the local conditions, especially on the volume of the enclosure of the explosive atmosphere. Even severe damages can be explained with only a small part of the enclosure containing an explosive atmosphere. In closed rooms already mixtures of 10 l can be hazardous.
Ignition:	The process which initiates a self-propagating combustion. ISO: Initiation of combustion
Ignition temperature:	Minimum temperature at which a dispersed phase explosive mixture can be ignited. ISO: Minimum temperature at which sustained combustion can be initiated under specified test conditions
Physical Explosion:	Sudden bursting of a container by failure or/and overpressure, otherwise sudden release of surface energy in bi-phasic systems (from bubbles in liquids or pores in solid materials)
Scene-log	Record of all attendees at the scene
Spark:	ISO: <electrotechnical> Luminous discharge resulting from the dielectric breakdown of a gas between two electrodes ISO: <mechanical> Incandescent particle
STP:	Standard Temperature and Pressure also known as NTP (Normal Temperature and Pressure)
Unconfined Vapour Cloud Explosion (UVCE):	Explosion by the ignition and subsequent burning of gas, vapour, mist and/or dust in the ambient atmosphere

APPENDIX B1 - INVESTIGATING FIRE FATALITIES

1 INTRODUCTION

When human remains are found or suspected to be within a fire scene their recovery must be undertaken by practitioners who have the competence to do so. However, all fire scene investigators must have an awareness of how such remains should be preserved and protected during the fire scene investigation process.

2 HEALTH AND SAFETY

There are a number of specific risks associated with the location and recovery of human remains within a fire scene. These risks vary in type and severity depending on the degree of damage to the body. Full personal protective equipment (including masks and goggles) for biological hazards must be worn based on the hazards identified. Counselling must be available for anyone who comes in contact with human remains.

2.1 Sharps

As a result of the fire, a body is exposed to both heat and impact damage for example due to falling debris and structural collapse. Loss of soft tissue due to heat can expose fractured bone which in turn pose a sharps risk to those handling the remains.

2.2 Biological hazards

Soft tissue damage can expose internal organs and bodily fluids which can contain potentially harmful bacteria and virus; these in turn pose a risk to those handling the remains both by inhalation and by direct contact. Fire investigator must take special precautions when examining fatal fires where there has been a positive conformation for infectious diseases.

2.3 Psychological risks

Observing and handling human remains carries the potential for psychological distress.

3 GENERAL INDICATORS OF THE PRESENCE OF HUMAN REMAINS

The physical condition of human remains will vary dependent upon the severity of the fire and/ or the length of time which the body has been exposed to the heat flux within the fire scene. Heat and fire fighting activities can cause extensive fragmentation and dispersion of the remains however the remains are still present within the scene to be recovered. The stages of damage listed below are not clearly defined but are part of a dynamic process that will vary on a scene by scene basis.

- Minimal heat damage,
- Pugilistic pose associated with some soft tissue damage
- Pugilistic pose associated with fragmentation of limb bones and exposure of the skull.
- Extensive loss of soft tissue, fragmentation of limb bones, exposure and fragmentation of skull and ribs, some loss of tissue and fragmentation of torso.
- Complete loss of soft tissue and fragmentation of bones, those left powder on touch.

4 SCENE EVALUATION

If human remains are suspected to be present in a scene at any stage of the scene examination, standard operating procedures for the recovery of human remains should be initiated and re-evaluation of the risks and handling of the scene must be carried out. Consultation with the appropriate specialist/expert must be part of this process of re-evaluation, such specialists could include a forensic pathologist/anthropologist etc.

In cases where the recovery of human remains is required, the following procedures must be followed;

1. The location of the body (including nearby debris on or surrounding the body and protected areas under or near the body) must be recorded and include a measured plan of the environment.
2. The position of the body must be recorded.
3. Photography of the teeth and fingerprinting should be considered prior to handling of the body depending on its condition.
4. Handling of the remains must be kept to a minimum.
5. Based on the condition of the body and the agreed scene examination strategy, samples (fingernail scrapings, biological evidence, trace evidence, clothing etc.) may be taken *in situ*. This is particularly the case if areas of the body have been protected from the effects of the fire for example by clothing or fallen debris.
6. Personal possessions and any clothing or wrapping associated with the body must be photographed and documented *in situ* prior to recovering, packaging and labelling.
7. Where applicable the body should be turned over within the scene and photographed. The area underneath the body should be recorded and carefully excavated and may be analysed for possible accelerant.
8. For bodies that have become fragmented, the fragments may have spread as a result of fire suppression activities and all attempts should be made to maximise the recovery of these fragments in such cases consultation with forensic anthropologists or forensic pathologists is advisable to ensure maximum recovery. Discussing fire suppression activities with the first responders will help in this respect. The location of all fragments must be recorded.
9. For situations where bone is exposed and has become fragile through heat exposure, stabilising chemicals or wrapping materials (such as cling film) can be considered if their use prevents further fragmentation or deterioration. Chemicals must be used with extreme caution and control samples of any chemicals and wrapping materials should also be supplied.
10. Body fragments can adhere to other items of debris and this debris should be carefully checked prior to removal from the scene.
11. In scenes where human remains are in danger of further damage and the body cannot be recovered quickly, it is the role of the fire investigator to initiate contact with the appropriate specialists as soon as possible and act upon the advice of these specialists in relation to the protection of the remains.
12. Human remains must be placed in cold storage as soon as possible after recovery.



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