



Best Practice Manual: Investigation of Fires and Explosions

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ENFSI Secretariat

Bundeskriminalamt KT-AS

65173 Wiesbaden, Germany

Phone +49 611 55 16660

E-mail secretariat@enfsi.eu

Website www.enfsi.eu

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ENFSI wishes to promote the improvement of mutual trust by encouraging forensic harmonization through the development and use of Best Practice Manuals.

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The latest version of this guidance document, version 5, has been a collaboration between the working group and its Steering Committee's Taskforce:

Benny Thomsen^a
 Eric Leung (Editor)^d
 Eva Ljungkvist^a
 Graham Strong^b
 Karen Robertson^b
 Niamh Nic Daéid^a
 Oleksandr Shmereg^c

^a Leverhulme Research Centre for Forensic Science,
 University of Dundee, UK

^b SPA Forensic Services, UK

^c The State Scientific Research Center, Ukraine

^d University of the West of England, UK

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Table of Contents

1. AIMS.....	7
2. SCOPE	8
3. TERMS AND DEFINITIONS	9
4. RESOURCES	10
4.1 Personnel	10
4.1.1 Allocation of Responsibilities.....	13
4.1.2 Collegiate Approach.....	14
4.2 Equipment	14
4.3 Reference materials	15
4.4 Facilities & Environmental Conditions	15
4.5 Risk-Based Thinking.....	15
4.6 Materials and Reagents.....	16
5. METHODS.....	17
5.1 Responding to a Call	17
5.1.1 En route and near to the scene.....	17
5.1.2 Approaching the scene	18
5.2 At the Scene	18
5.3 General Information for Documentation.....	18
5.4 Initial Scene Preservation.....	20
5.4.1 Scene Security.....	20
5.4.2 Path of Entry	20
5.5 Communication and Coordination	21
5.6 Tactical Information	21
5.6.1 Information from Witnesses	22
5.6.2 Information from Technical Systems.....	22
5.7 Technical Investigation	23
5.7.1 The Scientific Method	23
5.7.2 General	24
5.7.3 Interpretation of Available Information	25
5.7.4 Investigation Strategy	25
5.7.5 Initial Overview	27

5.7.6 Surroundings	27
5.7.7 Exterior	27
5.7.8 Interior, Fatalities and People	28
5.7.9 Glass Panes and Openings	29
5.7.10 Setting the Physical Boundaries of the Area of Investigation	29
5.8 Excavation	29
5.8.1 Stratigraphic Excavation	30
5.8.2 Physical Methodology of Excavation	30
5.8.3 Mechanical Excavation and Organisation of Workforce	31
6. VALIDATION AND ESTIMATION OF UNCERTAINTY OF MEASUREMENT ..	31
6.1 Validation	31
6.2 Estimation of uncertainty of measurement	33
7. QUALITY ASSURANCE	34
7.1 Proficiency Testing / Collaborative Exercises	34
7.2 Quality Controls	34
7.3 Data Collection for control, monitoring and trend analysis	35
7.4 Verification / Peer Review	36
8. HANDLING ITEMS	36
8.1 At the scene	36
8.1.1 Dialogue with the First Responder / Attendee	36
8.1.2 Recording In Situ	37
8.1.3 Sampling	37
8.1.4 Technical Systems	39
8.1.5 Fatalities	40
8.1.6 People of interest (witnesses, suspects, accused)	41
8.1.7 Documents	41
8.1.8 Spontaneous Combustion	41
8.1.9 Packaging/ Removal of Fragile Items or Items Likely to be Damaged	42
8.1.10 Maintenance of Sampling Equipment	42
8.2 In the laboratory	42
9. INITIAL ASSESSMENT	43
9.1 Determining the area or point of origin	43
9.2 Determining the potential causes of the fire	43
10. PRIORITISATION AND SEQUENCE OF EXAMINATIONS	44
10.1 Safety Assessment	44
10.2 Orientation and Investigation Planning	44

10.3	Key Prioritization Factors.....	45
10.4	Investigation Sequence	45
11.	RECONSTRUCTION	45
11.1	Reconstruction of a Fire Scene	45
11.2	Fire Tests/Experiments.....	46
12.	ASSESSMENT OF RESULTS AND INTERPRETATION	46
12.1	Analysis and hypothesis	46
12.1.1	Develop hypothesis (or hypotheses).....	46
12.1.2	Divergent and Convergent Thinking in Hypothesis Development	47
12.1.3	Testing the hypothesis (or hypotheses)	48
12.1.4	Final hypothesis.....	50
12.1.5	Bayesian Approach.....	50
12.2	Conclusion.....	50
13.	PRESENTATION OF RESULTS.....	51
14.	HEALTH AND SAFETY	51
14.1	Safety and Working Conditions	52
14.2	PPE and RPE	53
14.3	Further Information	54
15.	BIBLIOGRAPHY	55
16.	AMENDMENTS TO PREVIOUS VERSION	61
	APPENDIX A – TASKS FOR FIRST RESPONDERS.....	63
	APPENDIX B – INVESTIGATION STRATEGY WITH CASE STUDIES EXAMPLES.....	65
1.	Forensic Strategy Process.....	65
2.	Forensic Strategy Meeting	66
3.	Strategy for Imaging the Scene	66
4.	Who should be present at a Forensic Strategy Meeting?	67
5.	Examples of cases where Forensic Strategy may be amended	67
	APPENDIX C - PROTECTIVE CLOTHING.....	69
	APPENDIX D – INVESTIGATION OF VEHICLE FIRES.....	70
1.	Information Gathering	70
2.	Factual information to note:	70
3.	Initial Observations	71
4.	Safety Considerations.....	71
5.	Vehicle Examination	71
5.1	Checking the Fuel System.....	73
5.1.1	Hybrid and Electric Vehicles	74

5.2	Checking the Lubrication Systems	74
5.2.1	Diesel-Engine Vehicles	74
5.3	Checking the Cooling System.....	75
5.4	Checking the Electrical and Electronic Systems.....	75
6.	Location of the area(s) of origin	75
7.	Identify potential ignition sources.....	76
8.	Additional Information	76
9.	Taking of Samples	77
10.	Electric vehicles and Li-ion batteries	77
10.1	Identifying an EV/HEV	78
10.2	Additional Risks and Mitigations	78
10.3	Investigation Process	80
10.4	Extra Considerations	81
10.4.1	Burn Patterns	81
10.4.2	Fire-fighting Activity	81
10.4.3	Electrical Examination	81
10.4.4	Digital evidence	82
10.4.5	Collision damage	82
10.4.6	Charging System and Infrastructure	82
10.4.7	Vehicle History and Supporting Information.....	82
10.4.8	Further Reference Material	83
10.5	Considerations for investigation of lithium-ion battery fires (excluding vehicles)	83
11.	Other Transportation Vehicles.....	84
APPENDIX E – EXPLOSION INVESTIGATIONS		85
1.	Resources	85
2.	Methods.....	86
2.1	Gathering of information	86
2.2	Liaison	86
2.3	Health and Safety	87
2.3.1	Identification and Management of Hazards	88
2.3.2	Additional Hazards.....	88
2.4	Scene Examination and Investigation Strategy	89
2.4.1	Specific Considerations for Physical Explosions.....	90
2.4.2	Further Research.....	90
2.4.3	Experimentation and Analysis.....	90

2.4.4 Circumstances of the Incident.....	91
2.5 Handling of Items.....	91
2.6 Sampling and documentation	92
3. Source of ignition	93
4. Effects from Different Types of Explosions	93
4.1 Diffused-phase explosions	94
4.2 Condensed-phase explosions	94
4.3 Physical explosions	95
4.4 Boiling Liquid Expanding Vapour Explosions (BLEVEs).....	95
4.5 Investigation Considerations	96
5. Density and Buoyancy of Gases and Vapours	96
6. Boiling Point and Vapour Pressure	97
7. Flashpoint and Explosive Limits	97
8. Auto-ignition Temperature	98
9. Processing a condensed-phase explosion scene	99
9.1 Scene Examination.....	100
9.2 Potential Evidential Materials.....	100
9.3 Reconstruction and Analysis	100
9.4 Investigation Considerations	101
10. Area or Point of Origin.....	101
APPENDIX F - INVESTIGATING FIRE SCENES WITH FATALITIES.....	103
1. Introduction.....	103
2. Health and safety.....	103
2.1 Ergonomic	103
2.2 Sharps	103
2.3 Biological hazards	103
2.4 Psychological hazards.....	103
3. General indicators of the presence of human remains	104
4. Scene evaluation	104
APPENDIX G – CLANDESTINE MANUFACTURE OF DRUGS AND EXPLOSIVES	106
1. Drugs laboratory	106
1.1 Introduction.....	106
1.2 Health and Safety	106
1.3 Chemicals.....	106
1.4 Structural modifications	107

1.5	Equipment	107
1.6	Booby Traps	107
1.7	General Indicators	107
1.8	Scene Evaluation.....	108
2.	Homemade explosives	113
2.1	Introduction.....	113
2.2	Health and safety.....	114
2.3	General indicators of clandestine manufacture of explosive substances..	114
2.4	Scene evaluation	115
APPENDIX H – WILDFIRES.....		116
1.	Fire Danger Assessment	116
2.	Remote Sensing and Fire Detection	116
3.	Factors Influencing Wildfire Ignition and Development.....	116
4.	Interaction of Contributing Factors.....	117
5.	Dryness and Fuel Moisture Indicators	117
6.	Indicators of Fire Spread and Direction	117
7.	Common Causes of Wildfires	118
8.	Further Learning Resources	118
9.	Documentation	118
APPENDIX I – REPORTING OF RAPID INVESTIGATIONS.....		119
1.	General Principles	119
2.	Investigations Conducted Under Exceptional Constraints	119
3.	Adaptive Investigation Approaches.....	119
4.	Specialist Involvement	119
5.	Reporting Considerations	120
6.	Documentation and Record Keeping	120
7.	Digital Tools and Information Management	121
8.	Organisational Requirements	121
APPENDIX J – Determination of Cause of Ignition and Examples of Common Causes of Fire		122
APPENDIX K – CASE NOTES		124
1.	Example of a general fire investigation pro forma	124
2.	Example of a wildfire fire investigation pro forma.....	127
APPENDIX L – EDUCATION AND TRAINING		128
1.	Introduction	128
2.	Reference key documents	128

3.	Pre-training learning and reading	128
4.	Scope	129
5.	Learning objectives/outcomes	129
6.	Identifying training materials and use of ground truth materials for training.....	129
7.	Review at midpoint or milestones of training	130
8.	Maintenance of competence defined	130
9.	Assessment	130
10.	Feedback from trainees	130
11.	Review of training documentation	131
12.	MAINTAINING COMPETENCE AND CONTINUing PROFESSIONAL DEVELOPMENT	131
	APPENDIX M – LEVERAGING EMERGING OR NEW TECHNOLOGIES AND ANALYTICAL TECHNIQUES	132
1.	General Principles	132
2.	Internet of Things (IoT) Devices.....	132
3.	Investigative Opportunities Provided by IoT Systems.....	132
4.	Vehicle Data and Connected Transport Systems	133
5.	Potential Benefits for Fire Investigation	133
6.	Limitations and Challenges.....	133
7.	Digital Vehicle Forensics	134
8.	Specialist Support.....	134
	APPENDIX N - GLOSSARY OF TERMS.....	135
	APPENDIX O - ABBREVIATIONS.....	140

1. AIMS

The ENFSI Fires and Explosions Investigation Best Practice Manual (hereafter referred to as BPM) aims to provide a contemporary framework for investigation procedures supported by quality assurance and control principles. The intended audience for the BPM is fire and explosion investigation professionals, from both the public and private sectors. It offers recommendations for investigating a fire and/or explosion scene to achieve the best possible outcomes. Thus, this BPM can be used by member laboratories of ENFSI and other forensic science laboratories to establish and maintain working practices for the forensic examination of fire and explosion scenes that deliver reliable results, maximise the quality of the information obtained, and produce objective and robust evidence. The use of a consistent methodology and the production of more comparable results will facilitate data exchange between laboratories.

The term BPM is used to reflect a scientifically accepted best practice at the time of publication. It does not imply that the practices in this manual are the only acceptable or good practices used in the forensic fire and explosion investigation. It is acknowledged that there are nuances between different organisations and under various jurisdictions. In this series of ENFSI Best Practice Manuals, the term BPM has been maintained for continuity and recognition.

This BPM combines current available knowledge and information, along with results from an extensive study of the latest practices used by ENFSI member state forensic science laboratories and institutes.

From the publication date, the BPM shall be reviewed biennially by the FEIWG Steering Committee to ensure that it is aligned to contemporary standards, expressed with clarity, and remains relevant and applicable across all ENFSI member state institutes.

2. SCOPE

This BPM is an overarching document covering fire and explosion scene investigation. The guidance in the main body of this document applies to the most common types of fires and explosions, including diffuse-phase explosions. Additional guidance for less commonly encountered fires and explosions, or those of a specialist nature, e.g. electric vehicle fires or condensed phase explosions, may be found in the appendices of this document (please refer to the Table of Contents for the complete list of specialist topics).

This BPM is aimed at practitioners in fire and explosion investigations and assumes prior knowledge of the discipline. However, other professionals, e.g. forensic scientists from other disciplines, lawyers, or emergency responders, may find some of the information in the document useful. **The BPM is not intended to be a standard operating procedure and should not be treated as such.** It provides only guidance on what the ENFSI community considers as best practice. The BPM addresses the requirements of judicial systems only in general terms. While this document provides recommendations and refers to practitioner competence, training, exhibit handling and storage, etc., it does not address the specifics of laboratory examination of items, or how the individual competence of practitioners (including training requirements) is considered or accepted as achieved, nor does it address specific country- or jurisdiction-specific legal requirements.

This document is a guide, and it is recommended that it should be used in conjunction with:

- other ENFSI practical and reporting guidelines, for example:
 - BPM for Scenes of Crime Examination https://enfsi.eu/wp-content/uploads/2022/02/BPM-SOC-01-v.20220214_final_v2.pdf
 - Guidance for Evaluative Reporting in Forensic Science https://enfsi.eu/wp-content/uploads/2016/09/m1_guideline.pdf
 - BPM for the Forensic Recovery, Identification and Analysis of Explosives Traces <https://enfsi.eu/wp->

[content/uploads/2016/09/9. forensic recovery identification and analysis of explosives traces 0.pdf](#)

- procedures and documentation required by specific national legal and investigative authorities, e.g. health and safety protocols and legal requirements of expert witnesses

3. TERMS AND DEFINITIONS

For the purpose of this BPM, fire scenes shall mean scenes that involve fire damage and/or diffuse-phase explosions. For consistency and brevity, any reference to fire investigation or investigation of fire scenes shall mean the investigation of fires or diffuse phase explosions. Similarly, any reference to Fire Investigator (FI) shall mean someone competent to investigate fires and/or diffuse-phase explosions.

This BPM provides practitioners with guidance to ensure that the risk of pertinent information being lost or not captured is minimised. Broadly, an investigation covers five phases of activity (see Figure 1). For each phase, the FI's role is outlined.

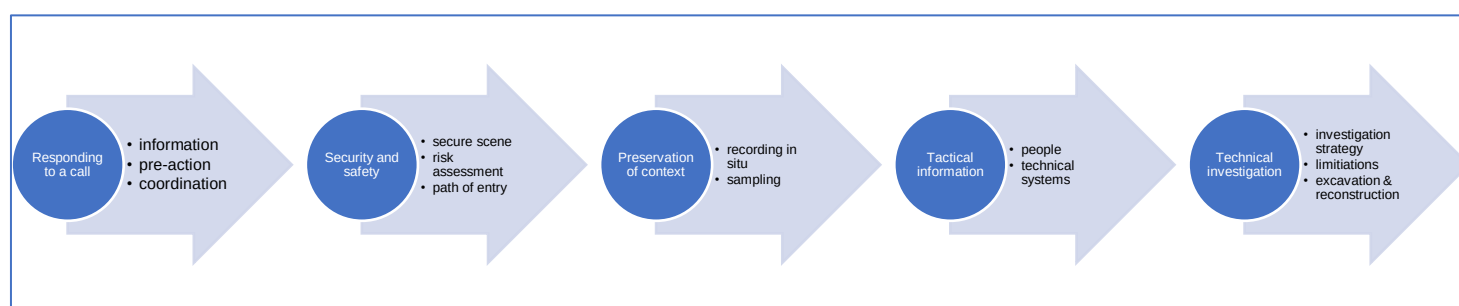


Figure 1. Stages of an investigation.

The different phases should not be considered as separate entities, and during some investigations there is no strict chronological order for their execution. They are interwoven and the activities in each phase can link directly or indirectly to those in other phases.

It is important that the practitioner understands the limitations of their knowledge and expertise. It is better to ask an appropriate specialist for assistance than to risk an inaccurate or incomplete investigation or mistakes that may lead to a wrong conclusion and, potentially, a miscarriage of justice.

Personnel involved in the preservation and investigation of the scene of a fire or explosion may be classified into three categories (Table 1):

Table 1. Definitions of Personnel

Name	Definition
First responder (FR)	The first official person or agency to arrive at a scene (for example, police, fire, or ambulance services), typically responsible for initially securing and preserving it.
Fire Investigator (FI)	A qualified professional appointed by the first responder or investigating agency to determine the origin, cause, and development of a fire or explosion.
Specialist	A professional with advanced knowledge, skills, and experience in a specific field. A specialist may be a fire and explosion investigator with additional expertise (for example, electric vehicles or condensed-phase explosions), or an expert from another discipline whose knowledge supports the investigation (for example, a forensic biologist or pathologist). Specialists may be appointed by the fire investigator or the investigating agency.

The functional boundaries between the categories of personnel described above may not always be clearly defined. Examples of the responsibilities of first responders are described in [Appendix A](#).

The responsibility for determining the origin, cause and development of a fire and/or explosion generally falls to the FI. It is widely acknowledged that each fire has its challenges. A fire investigation, which initially seems routine, may turn out to be complex and thus may require the assistance/input of a specialist, or be handled by a specialist. An FI or specialist may determine the origin, cause and development of a fire and/or explosion; the extent of such involvement will depend on the individual's competence, the circumstances of the case and the local jurisdiction.

For this BPM, the relevant terms and definitions given in ENFSI documents, ILAC G19 "Modules in Forensic Science Process", and international quality management system standards, such as ISO 9000, ISO/IEC 17000, ISO/IEC 17020, ISO/IEC 17025 and ISO 21043, apply. ENFSI's BPM for the Implementation of a Quality Management System and Accreditation Model for Crime Scene Investigation should be consulted ([AFORE-WP2-BPM Accreditation-SoC-1.pdf](#)). Where applicable, other definitions are presented in each of the sections and appendices.

A Glossary of Terms can be found in [Appendix N](#) of this BPM.

4. RESOURCES

Management of the resources required for a fire scene investigation must take into consideration the requirements of relevant quality standards, e.g. personnel competence, equipment maintenance and anti-contamination procedures. It must also be recognised that many aspects of fire scene investigation will not be specifically addressed in such standards. It is the responsibility of the FI (and their organisation) to ensure that the requirements of those standards are met.

4.1 Personnel

FIs have a wide variety of experience, training, and background knowledge, which can be obtained through different routes (e.g. academic studies, continuous professional development, vocational training, operational experience, etc.). See also [Appendix L](#) "Education and Training" for additional information.

The FI(s) and specialist(s) must demonstrate that they have the necessary competence and experience that are relevant to the task at hand. In line with quality management principles and requirements, such competence must be continually maintained and documented by objective evidence.

FIs must be competent and, where applicable, trained in accordance with their organisational or relevant national standards. Such standards should be described by an organisation's quality management system and/or underpinned by international quality management standards and accreditation. An in-house training manual and competence procedure that detail how initial competence is assessed and attained, and how ongoing competence is maintained, should be implemented. Table 2 lists examples of competencies, knowledge, and skills; the list is not exhaustive.

Table 2. Recommended FI competencies, knowledge and skill set

	Competencies
1.	Understanding the importance and relevance of health and safety at scenes and that this may vary depending on the nature of each scene. Being able to conduct a thorough H&S risk assessment at a scene.
2.	Understanding the importance of adopting the scientific method to fire scene investigation (i.e. a structured, systematic and methodological approach via making observations, collecting, analysing information/data, and formulating and testing hypotheses iteratively). Awareness of the Bayesian statistical approach to evaluating the evidential value of a piece of evidence or an observation. Understanding that the scientific method and the Bayesian approach are not mutually exclusive.
3.	Understanding aspects of fire science and fire engineering that may be relevant to fire investigation, e.g. fire dynamics, structural performance, passive and active fire protection systems, fire tests, and human behaviour in fire scenarios (DiNenno <i>et al.</i> , 1988; Gorbett, Pharr and Rockwell, 2021).
4.	Understanding the mechanisms of heat transfer.
5.	Understanding the differing types and mechanisms of ignition (Babrauskas, 2003).
6.	Understanding the physical and chemical properties of solid, liquid and gaseous fuels and materials as they relate to their combustion and pyrolysis (thermal decomposition) 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, e.g. building systems, construction design and materials, building structure and geometry, building/room contents (fuel load), ventilation and installed passive and active fire protection systems.
8.	Awareness of how automobiles work, including electric vehicles, and the common causes for them to catch fire (Zhang <i>et al.</i> , 2024).
9.	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.
10.	Understanding the potential role of electricity in causing fires and the post-fire indicators of electrical involvement.
11.	Awareness of the importance of the examination of circuit protection devices and electrical appliances and the appropriate means of securing and recovering electrical appliances post fire. Ability to examine circuit protection devices and electrical appliances. Examples of circuit protection devices include but are not limited to fuses, cartridge fuse, miniature circuit breaker (MCB), moulded case circuit breaker (MCCB), residual current device (RCD) or residual current circuit breaker (RCCB), residual current circuit breaker with overcurrent protection (RCBO), surge protection device (SPD), arc-fault circuit interrupter (AFCI), ground-fault circuit interrupter (GFCI), etc.
12.	Awareness of diffuse phase explosions, including the pattern of damage, e.g. explosions due to the ignition of fuel/air mixture from mains gas or finely divided solid particles.
13.	Awareness of condensed phase explosions, including their post-blast indicators, and able to tell the difference between these and diffuse phase explosions.

	Competencies
14.	Understanding the factors which may contribute to fire fatalities, including aspects such as toxicity of products of pyrolysis and combustion, formal and/or viable escape routes and inherent functioning/defunct/damaged fire detection/protection systems.
15.	Understanding the procedures relating to the recovery of evidential items (including human fatalities) from fire scenes. Able to recover evidential items and preserve their integrity, continuity and chain of custody.
16.	Understanding the requirements for contamination control and using appropriate packaging materials and understanding the importance of control and comparison samples in the collection of fire debris suspected to contain ignitable liquid residues (Borusiewicz, 2002; Stauffer, Dolan and Newman, 2007; Buc <i>et al.</i> , 2008).
17.	Understanding of the general characteristics that suggest the production of either prohibited chemical substances or homemade explosives, improvised incendiary and explosive devices (IIDs and IEDs). See Appendix G – “Clandestine Manufacture of drugs and explosives.
18.	Understanding of the FI’s role and responsibilities in relation to interviewing witnesses, where applicable, taking into consideration national legal requirements.
19.	Understanding that fire scene investigation is a destructive examination process that makes original observations nearly impossible to re-examine. Hence, an understanding of the importance of scene preservation (and recording) such that a scene should be preserved as far as practicable so that it may be examined by other interested parties later.
20.	Able to keep accurate and original records of casework. Able to make a comprehensive record/documentation of the scene investigation using a combination of techniques, e.g. written notes, sketches, voice recordings, photography, photogrammetry, 3D-scanning, videography and arial drone footage. Where possible, critical evidence and findings should be recorded in multiple formats for corroboration.
21.	Able to prepare reports and/or statements appropriate for the national justice systems. Give testimony and communicate their involvement in the case, their findings and conclusions in an objective, transparent, traceable, and appropriate manner within their field of expertise. Where possible, alternative hypotheses should be considered and presented in the interpretation of the findings.
22.	Awareness of latest technological developments that can provide useful assistance and information in the investigation of fires and explosions (Evans, 2023), e.g. Internet of Things (IoT) (Servida <i>et al.</i> , 2023; Grispos, Studiawan and Alrabaee, 2024).
23.	Understanding of local working practices in relation to multi-agency responses to fire and explosion scene investigation.
24.	Awareness of the difference between a fire scene investigation strategy and a forensic case strategy. Often, the two are the same, but sometimes the latter implies a broader investigation context and a deeper case complexity.
25.	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.
26.	Understanding the requirements of local criminal justice systems and in particular the rules of evidence and the obligations of being an expert witness for the courts.

The FI 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 if:

- the expert's scientific, technical, or other specialised knowledge will help the court to understand the evidence or to determine a disputed fact (Petrovich, 1998; The Royal Society, 2023; Peck, 2024; Nic Daéid and Carey, 2025)
- their testimony is based on sufficient verified facts and/or objective 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

A conclusion will qualify as scientific findings if the FI/specialist can demonstrate that it is the product of a sound scientific method preferably supported by relevant statistics and scientific reasoning. Otherwise, the finding may be considered as purely subjective.

The 'scientific method' is a stepwise and iterative process. It involves making observations, collecting data, formulating and testing hypotheses to arrive at fact-based conclusions. For more information on the scientific method, please refer to [Section 5 "Methods"](#) of this document.

Every scene should be considered and, wherever possible, utilised as a training (and mentoring) opportunity for staff development, enhancing an operational team's overall experience.

Having acquired and attained their initial competence as defined by the practitioner's organisation and/or national standards, the practitioner should maintain and further develop this competence. The process by which this is achieved is a matter for the practitioner's organisation to define and it should be fully documented, as required by various ISO/IEC accreditation standards.

For example, ongoing competence may be demonstrated through in-house competence assessments, annual on-site reviews, and/or participation in proficiency trials or interlaboratory collaborative tests.

4.1.1 Allocation of Responsibilities

All scene activities undertaken, including its preservation and the protection/recovery of potential evidential material, must be communicated to the appropriate parties/agencies as soon as practicable. The allocation of responsibilities will form part of the agreed investigation strategy. Please refer to [Appendix B "Investigation Strategy"](#) for additional information. When assistance is required in specialised fields, expert advice must be sought. Where assistance is sought, a specialist should preferably, though not essential, have experience of working within fire scenes.

The following is a selection of professionals or organisations who could be of assistance during fire scene investigations (this is not an exhaustive list):

- scientists from other forensic disciplines, e.g. chemists, biologists, anthropologists
- medical examiner/pathologist
- electrical engineer, e.g. from a National Electrical Safety Board
- mechanical engineer
- automobile mechanics or engineers (with knowledge of Li-ion battery, hydrogen fuel cell or LPG fuel systems/assemblies)
- gas engineer, e.g. from a National Gas Safety Board

- fire protection engineer
- buildings surveyor
- heating appliances experts
- CBRN professionals
- DVI professionals
- Fire and Rescue Service
- National Maritime Administration
- chimney master/sweeper

The FI must also consider which parties/authorities to inform regarding wider community fire protection programs, e.g. product manufacturers, insurance companies, etc.

4.1.2 Collegiate Approach

‘Collegiate approach’ means an investigation team composed of various colleagues of equal standing, for example (this is not an exhaustive list):

- forensic FI
- forensic locksmiths
- forensic motor vehicle examiners
- forensic electrical engineers
- loss assessors/adjustors
- private sector investigators

A collegiate team approach helps to optimise the opportunities for the correct identification of the available physical evidence and define the scope of analysis or examination. This collaborative approach supports the determination of a fire's origin and cause. The agreed forensic case strategy should clearly set out the roles and responsibilities of each investigation team member.

4.2 Equipment

A variety of equipment may be used during a fire scene investigation, some of which is detailed in the latter parts of this BPM (e.g. [Section 5 “Methods”](#)). When using equipment, consideration should be given to the following:

- equipment should be calibrated and maintained according to the operating manuals
- periodic calibrations and calibration checks must be recorded in a logbook associated with the equipment
- a documented equipment maintenance procedure should be implemented
- all tools and non-disposable personal protective equipment (PPE) and clothing should be cleaned and free of contaminants, or replaced, between uses at different scene locations or situations where potential cross-contamination could be an issue.

For example, prior to entering a scene, and at the end of each scene examination, all reusable PPE, including protective boots and rubber gloves, and excavation tools could be washed with a non-solvent-based detergent to ensure that any potential for such equipment to transfer evidential material, such as hydrocarbon-based ignitable liquid residues or other trace evidence, from one scene to another is minimised.

Cleaned utensils and tools should be sampled prior to use, and the samples retained for further testing if required (e.g. tools and soles of footwear may be swabbed, with the swabs retained and tested).

All tools and non-disposable PPE and clothing that have been cleaned should be tested for contaminants before reuse. Cleaning and sampling records of such equipment should be kept and maintained. A documented anti-contamination and monitoring procedure should be implemented.

Additional considerations may include:

- environmental monitoring of the scene vehicles may also be necessary
- extra care must be taken to ensure that evidential material is not transferred onto electronic recording devices, such as cameras and voice recorders (e.g. remove any protective gloves when handling such devices)
- disposable PPE must be disposed of at the end of each scene examination
- where contamination may have occurred during a scene examination, this must be documented in the FI's scene notes
- equipment and tools must be regularly inspected and replaced if damaged to the extent that cleaning procedures are ineffective
- equipment must be stored in such a way that minimises the risk of biological or chemical contamination prior to use
- the testing of samples from cleaned equipment should be carried out by an accredited laboratory, e.g. one accredited to ISO/IEC 17025
- if contamination is identified, a root cause analysis should be carried out to determine the source(s) of the contamination, and a suitable process implemented to minimise the potential for recurrence.

4.3 Reference materials

Where scene equipment requires calibration before its use at a scene, such equipment must be calibrated against acceptable reference standards or materials in accordance with [Section 4.2](#).

4.4 Facilities & Environmental Conditions

There may be occasions when “evidential materials” are recovered and transferred to other more suitable locations for further examination under controlled conditions. For example, fatalities recovered to the mortuary, burnt vehicles recovered to examination suites in secure compounds, or items recovered to sites for large scale fire-testing.

Under such circumstances and where applicable, considerations must be given to ensure the environment is contaminant-free. Contaminant may include ignitable liquid residues or other trace evidence depending on the nature of the investigation.

4.5 Risk-Based Thinking

Risk-based thinking is a core principle of quality assurance in forensic science, including fire and explosion investigations. It requires investigators to proactively identify, assess, control, and monitor factors that could compromise the integrity, reliability, validity, and impartiality of investigative findings. Throughout scene examination, risks must be considered that could result in a substandard investigation, including contamination or loss of evidential material, incorrect scene interpretation, varied competence of personnel, poor documentation, equipment failures, and cognitive bias (Roux et al., 2022). Failure to manage these risks can lead to inaccurate origin and cause determinations, reduced confidence in findings, and potential miscarriages of justice.

A significant risk within fire investigation is cognitive bias (Almirall et al., 2017), where knowledge of witness accounts, investigative theories, insurance

considerations, or suspect information may unconsciously influence scene assessment and interpretation of fire patterns. These risks should be mitigated through the development of a formal case investigation strategy, controlled use of contextual information, adherence to standard operating procedures, structured scene assessment methodologies (Nic Daéid, 2004), peer review, technical review and regular training on bias awareness. Investigators should actively consider and document alternative hypotheses rather than seeking evidence solely to support an assumed cause. The principles contained within ISO 21043, particularly those relating to forensic process management and evaluative reporting, provide a recognised framework for reducing the influence of subjective interpretation and promoting objective forensic decision-making.

Risk management should be embedded within a robust quality management system supported by accreditation to recognised standards such as ISO/IEC 17020 for fire scene investigation activities and ISO/IEC 17025 where laboratory testing is undertaken. Accreditation promotes risk-based thinking by requiring organisations to identify risks to competence, consistency, validity, and impartiality, and implement proportionate controls. ISO 21043 complements these standards by providing forensic science-specific guidance across the entire forensic process, from scene examination and evidence recovery through to interpretation and reporting, ensuring that risks affecting evidential integrity and scientific validity are systematically addressed.

The effectiveness of risk controls should be monitored through internal and external audits, competency assessments, proficiency testing, and the investigation of non-conformities and near misses. Competency frameworks should ensure investigators possess and maintain the necessary knowledge, skills, and experience to interpret fire and explosion scenes, recognise evidential opportunities, and apply accepted scientific principles. Audit findings, quality indicators, proficiency testing outcomes, and lessons learned should be used to identify emerging risks and support continual improvement. These measures also provide assurance that organisational controls align with the requirements of ISO accreditation and the best-practice principles outlined within ISO 21043.

Particular attention should also be given to contamination risks, especially where ignitable liquid residues, trace evidence, DNA, explosives residues, or other forensic materials may be present (Blackledge, 2007). Anti-contamination controls should include scene security, controlled access, personal protective equipment, sterile sampling techniques, equipment decontamination, and robust continuity and traceability arrangements. Investigative organisations must also actively manage impartiality risks through documented policies, conflict-of-interest declarations, independent technical review, and safeguards against undue investigative, legal, commercial, or insurance-related influence.

By integrating risk assessment, accreditation requirements, competency assurance, bias mitigation strategies, impartiality safeguards, contamination controls, and the forensic science principles contained within ISO 21043, fire and explosion investigators can ensure that conclusions are scientifically robust, transparent, reproducible, and defensible. This approach supports the production of reliable forensic evidence and strengthens confidence in the findings presented to courts, insurers, regulators, and other stakeholders (The Royal Society, 2023; Peck, 2024; Nic Daéid and Carey, 2025).

4.6 Materials and Reagents

Packaging materials, e.g. nylon bags, Kapak/Ampac bags and metal cans, used for the recovery of evidential materials must be monitored and shown to be

contamination-free. The packaging materials should be sourced from accredited suppliers. A representative number of samples of the packaging material from batches received from suppliers should be tested, and the analytical results should be retained and maintained.

As and when a clean batch of packaging material is used at a scene, a control sample of the packaging material should be exhibited prior to the recovery of any evidential item that is suspected of having ignitable liquid residues on it. The exhibited control packaging can then be tested to ensure it has not been contaminated while in storage. This process may form part of a documented anti-contamination procedure mentioned in Section 4.2 above. Further guidance for sample recovery can be found in [Section 8 “Handling Items”](#).

5. METHODS

5.1 Responding to a Call

The FIs are not normally directly involved in the First Responder’s work/duties at the scene. The FI must ideally obtain the “data collection sheet” (an incident record completed by first attending emergency services) or similar information from a first responder and liaise with them to obtain the relevant information prior to attending the scene. See Figure 2 below for an outline of the common investigation phases.

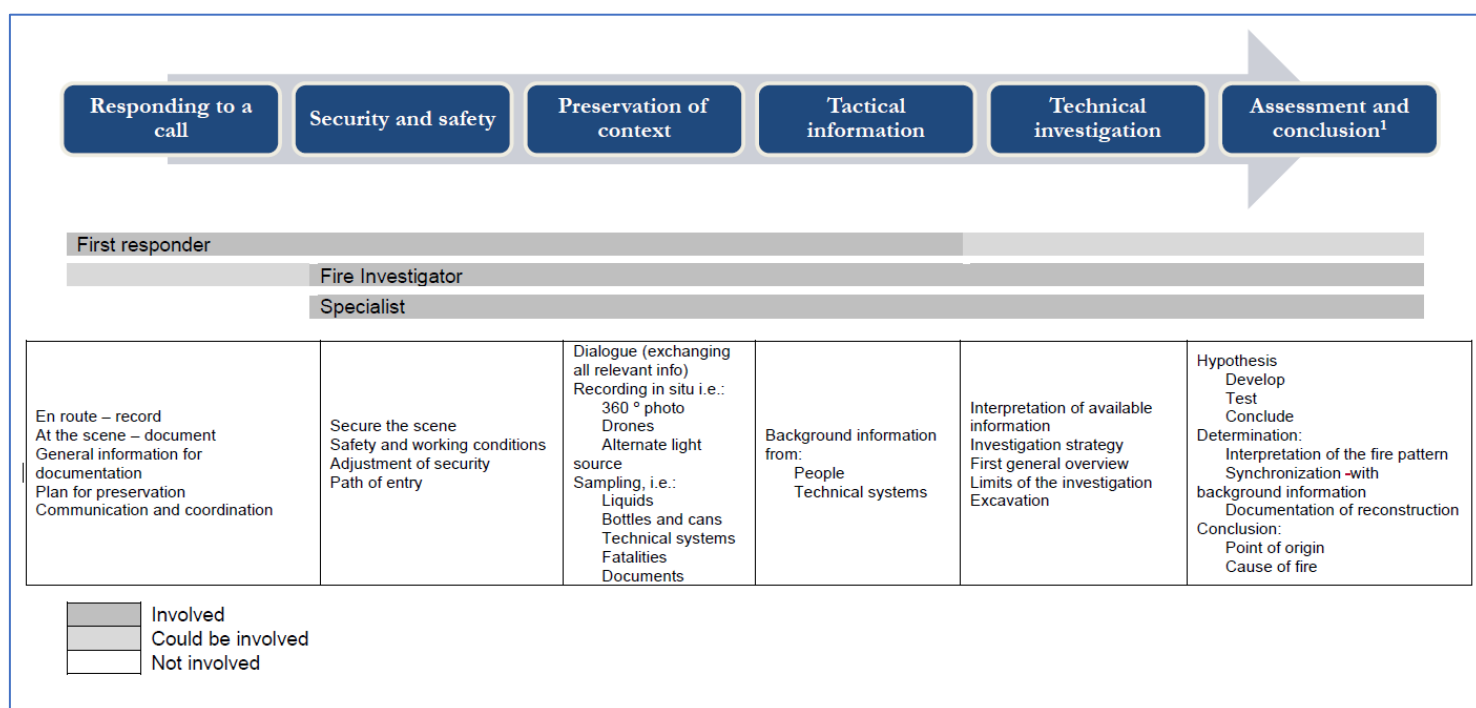


Figure 2. An illustration of common investigation phases. Note: Figure 2 is an extension of Figure 1 and adds an additional, final “Assessment and Conclusion” phase.

5.1.1 En route and near to the scene

Information to be recorded or obtained might include:

- time of call and any information initially given
- people present (witnesses, bystanders, reporters, others)
- vehicles present
- anyone seen leaving the scene
- unusual or specific activities of any individuals present

- prevailing weather conditions, e.g. wind speed and direction, and any significant changes in weather (such information may assist in explaining the fire's development and spread)

5.1.2 Approaching the scene

Information to be recorded or obtained:

- the FI's actions/activities (including a safety assessment)
- the number of fire appliances in attendance and the activities of firefighters
- the identities and behaviour of bystanders present at the scene, particularly those displaying unusual interest or behaviour
- photographs and video recordings of bystanders may be useful - such images and recordings should be documented, dated, and retained in accordance with relevant procedures
- the reactions and behaviour of the owner or occupant upon arrival at the scene, particularly when receiving information about the incident

For additional information on the following less-routine investigations please refer to their dedicated sections/appendices (see also the Table of Contents):

- fires with electric vehicles – [Appendix D](#)
- condensed phase explosions – [Appendix E](#)
- investigating fire scenes with fatalities – [Appendix F](#)
- clandestine drug and explosives laboratories – [Appendix G](#)
- wildfires – [Appendix H](#)

5.2 At the Scene

Take photographs and make notes as soon as possible to record the scene in its original condition. [Appendix K](#) ("Case Notes") provides examples of standard scene examination pro formas. Photographs and notes should capture the scene from multiple angles, such as the four corners of a room, and include areas not affected by fire.

If firefighting is still underway on arrival, photograph and, where possible, video the activities, paying particular attention to the location of smoke and flames. Ensure all photography and videography equipment is set to the correct date and time so that metadata and time stamps are accurate.

5.3 General Information for Documentation

At this stage, information can be gathered from the incident commander (or equivalent), firefighters, witnesses, property owners, tenants, and neighbours. Early collection of such information can provide valuable context for the investigation. However, investigators should remain alert to confirmation bias when examining the scene and assessing findings. Relevant sections of the case notes should be completed where applicable.

Table 3 provides examples of information that may be important to obtain before commencing the examination. These questions and items are illustrative rather than exhaustive, and additional enquiries may be required depending on the circumstances of the fire.

Table 3. Examples of information of importance

	Property owner/ First person at the scene/Witness/Neighbours
The property	Are there any: - hazards present within the premises, e.g. asbestos, chemicals (ECHA, 2024), gas cylinders, unsafe building components, animals? - records relating to the security of the premises prior to the fire? - CCTV systems covering the premises or nearby areas? - fire/smoke/intruder alarms installed within the premises? If so, where were they located, did they operate, and are there details of their mode or sequence of activation? - photographs or video recordings of the fire, or of the premises before the fire, showing internal or external conditions? - building, structural, or utility drawings and plans, including those held by gas, electricity, local authority, or fire service organisations? - sketch plans of the building, rooms, and their contents? - electrical, heating, or other equipment that could have served as a potential ignition source in the area of interest? If so, what were the details? - ignitable liquids or materials, or materials susceptible to spontaneous combustion (Gray, 2008), present at the scene? - information relating to the area where the fire was first observed, including its contents and use? - standard operating procedures, activity records, or deviation logs relevant to the premises or activities conducted there? - data records, maintenance logs, or service records relevant to the premises, equipment, or systems involved?
Actions and people before the fire	- Had any candles, tealights, joss-sticks or incense burners been used? - Had any repair work, alterations, welding or any type of “hot work” been undertaken in the area? If yes, obtain the details (e.g. where, what, and when?). - Had anyone smoked in the area of origin? If so, when did this last occur, what was smoked, and how was the smoking material discarded? - Which activities were noticed in the surrounding area shortly before the fire? - Have there been any problems with appliances in the past? - Have there been any previous problems with the building’s utility services or fixed installations (e.g. electricity, gas and water supplies) or fire detection system? - If there was an intruder alarm, was it armed/active prior to the fire? Is there an alarm log? - Were any sounds heard before the fire? - Were the doors and windows closed when the last person left the area? - Were there any unusual smells that hadn’t been smelled before? - What were the actions of the last person in the room of origin/property? - When and how did that person leave the room of origin/property? - Where were the occupants when the fire broke out? What were they doing? - Who discovered the fire? What did they see? What was the lighting condition? - Which doors or windows were open when the fire was discovered? - Were any windows broken before the fire was discovered?
The fire	- What was the exact time of call? Who was the caller? - What of the fire was detected? Was it the smoke, flames or heat? - How did the fire develop? Are there thermal imaging camera records from handheld or drone mounted devices (FPV-IR) that can be reviewed? - Did any windows break before the firefighters arrive? If so, when and in what order? - How did people evacuate the building? - How high were the flames? Was the fire at high or low level? How intense was it? - How much smoke was produced? - What were the colours of the smoke and flames? - How much time elapsed between the fire being detected and the alarm being raised? - Was any attempt made to extinguish the fire? If so, what actions were taken and by whom? - What were the weather conditions at the time of the fire, including wind speed and direction, ambient temperature, ground conditions (dry or wet), and any precipitation?
Digital Traces	Digital data records, including timestamps and monitoring data, from sources such as: - internet service providers (ISPs) and smart home systems/devices - HVAC systems - weather stations - electricity meter - mobile phones (and installed applications) - social media platforms - access and login/logout records - swipe-card access systems in commercial or public buildings - vehicles (including key fobs) and manufacturer data, particularly for electric vehicles

5.4 Initial Scene Preservation

To ensure the integrity of the scene, make sure 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 to encompass all areas containing possible evidence.

The scene and any potential evidence within it need to be recorded accurately before any change takes place. Any modification to the scene or evidence within it before the arrival of the FI must be recorded and documented in detail. It may be necessary to protect items in situ if they are to be sampled or to recover/sample the items immediately, particularly where DNA may be critical to the overall investigation (such as from blood, container lids, bottles, etc.). The FI needs to ensure that the method of recovery or protection is carried out in a forensically accepted manner and that it does not contaminate or damage the article or trace evidence. It may be necessary to consult with a specialist to ensure that any preservation / recovery is carried out appropriately.

It is important for any subsequent investigation that nothing within the cordoned area is moved unnecessarily. While it is recognised that firefighting activities will result in the displacement 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 that need to be moved, damaged, or removed must be photographed in situ and noted (with the time and date) beforehand. Be aware that trace evidence, not visible to the naked eye (e.g. DNA and fingerprints), can be left at the scene by first responders or investigators. Appropriate anti-contamination precautions must therefore be taken (i.e. wearing forensic scene suits, gloves, masks, etc.).

5.4.1 Scene Security

Cordoning off a scene with tape alone is not sufficient to ensure the integrity of the scene. It may be enough to keep the public away, but it will not stop or prevent entry. For this to be as effective as possible a human presence at the cordon (police officer or firefighter) is preferable. This presence should 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 and record the times of entry and exit for all people entering and leaving 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) or of any other scenes that the party has attended which may be linked to the current scene. The FI should record their own times of arrival and departure for reasons of health and safety and/or to establish a timeline of events.

Bear in mind that the property owner or workers at the incident venue may be a suspect, their entry to and from the scene must also be closely monitored.

5.4.2 Path of Entry

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

Any item that may be potential evidence but is obstructing the common approach path must be photographed and noted in situ. It can then be recovered or protected to minimise any risk of damage or loss. Where possible, identify an unobstructed

approach path to the area of interest (e.g. the room or origin, the fire-damaged area, or the deceased), and use stepping plates if appropriate.

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

In any fatal or serious injury fire, or suspected arson, whenever practicable, the common approach path must not follow the normal approach to the area of interest/seat of the fire. Be aware that a perpetrator may have used the same path to enter or leave the scene.

5.5 Communication and Coordination

Be aware that the FI may be contacted by the first responder for advice before attending the scene. Such advice may include identifying relevant people to speak to and the type of information that might be required later.

All the information gathered must be shared with all appropriate parties, or investigating agencies, through agreed channels as soon as practicable or within agreed timescales. In addition, all activities undertaken to gather that information should be recorded and shared in the same way. All investigation work at the scene needs to be coordinated, communicated, and agreed upon by all parties. (See also [Section 4.1.1 “Allocation of Responsibilities”](#) and [Section 4.1.2 “Collegiate Approach”](#) for additional information.)

5.6 Tactical Information

The FI may find themselves with two general situations at a scene:

- fire propagation is limited, and it is therefore straight forward to locate the origin of the fire
- there is severe or complete destruction of a property, where extensive excavation and reconstruction may be required to determine the origin of the fire

Information gathered by others (e.g. police officers, fire service, and other first responders) may help the investigation in both scenarios. Figure 3 is an example of useful tactical topics to discuss.



Figure 3. Example of tactical information topics.

There are two types of tactical information: information from people and information that can be extracted from technical systems.

Before the examination, it is important to obtain as much relevant information as possible. First responders may have obtained information more suited to a tactical investigation than to a technical investigation. While this tactical information may assist the technical investigation, it is important to remember that it may contribute to cognitive bias.

5.6.1 Information from Witnesses

Obtain the data collection sheet (incident record or equivalent) from the first responder. If this has not been completed, ensure that the remaining required information is gathered. This may include photographs, videos, thermal imaging records, and/or incident recordings (e.g. fire service operation logs). 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 firefighters to return to the scene and recount 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. These may help to establish the area of origin. Social media can also be an important source of information and thorough search routines are recommended. A timeline of important events before, during and after the fire should be ascertained.

5.6.2 Information from Technical Systems

Consider interrogating any suitable technical system and, if it is connected to a remote call station, obtain the data logs. These logs may contain detailed information on the activation times of individual fire or intruder alarm detectors or sensors, allowing the investigator to map the spread of the fire. However, some of this information may be time-dependent, such as CCTV, smart electric meters, and alarm (fire or intruder detection) system information, and must therefore be documented and recovered by an authorised person at the earliest opportunity. Some key information sources to consider include, but are not limited to:

- pre-existing site drawings and plans (e.g. 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 (current and past)
- equipment manuals
- radio traffic
- emergency calls
- technical literature

All activities undertaken by a specialist to gather technical information together with the information collected must be communicated to the FI and investigating team as soon as practicable.

5.7 Technical Investigation

5.7.1 The Scientific Method

Fire investigation is a scientific process in which a systematic, iterative approach is used to answer specific questions about the fire, its development, and its potential causes (NFPA, 2024b). See Figure 4 for a visual illustration. This is carried out by collecting and recording data through the detailed examination of the scene.

This information/data is then evaluated and from this, the investigator formulates a number of hypotheses based on the evidence found at the scene, a process often referred to as inductive reasoning.

Each of these hypotheses is then suitably tested using the investigator's own knowledge, experience and expertise (a process often referred to as deductive reasoning), as well as, where applicable, fire tests or laboratory analysis of recovered samples, resulting in robust conclusions that allow an objective and optimal determination of the origin, cause and fire spread at the scene.

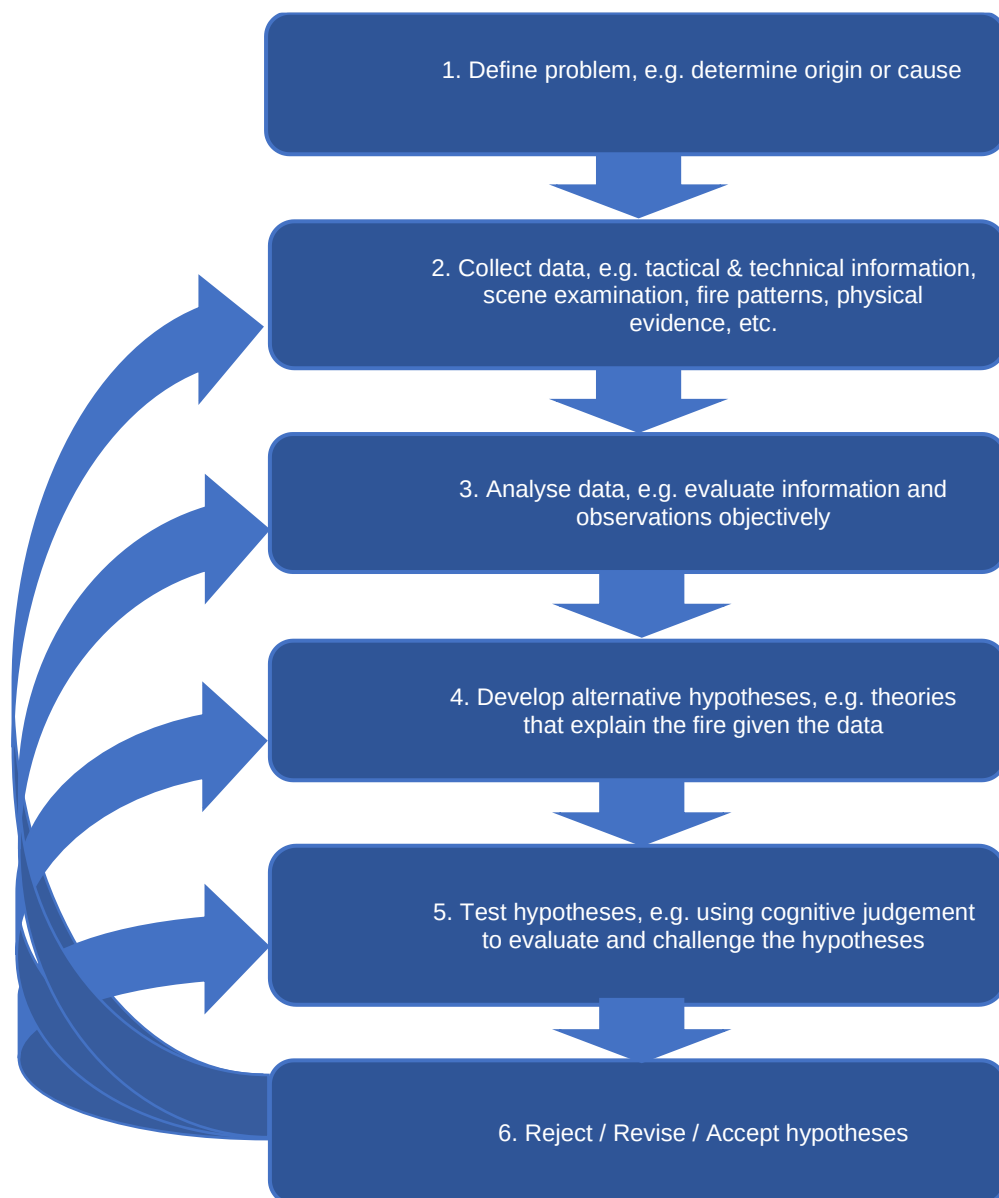


Figure 4. An illustration of the scientific method, adapted from NFPA (2024b).

To optimise the quality of their data interpretation, in addition to examining and assessing the fire scene using the scientific method, the FI may wish to include (where appropriate):

- other validated analysis techniques, e.g. Sequential Timed Event Plot (STEP), AcciMap (a systems-based technique for accident analysis)
- appropriate use of other validated technical methods using calibrated equipment, e.g. laboratory tests, fire experiments (Adolfson, 2015)

5.7.2 General

Prior to or upon arrival, the FI may be required to provide advice on preserving the scene, e.g. firefighting activities and coordination with scene commanders.

As part of the scene examination, a series of general photographs and videos may be taken as well as acquiring or preparing appropriate plans, drawings/sketches and diagrams. Videos can also be taken.

Accurate documentation and photography are essential. Where applicable, exterior documentation should include appropriate landmarks 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 provide context.

Documentation must also include the FI's observations and actions at the scene. These documents must be signed, dated, and retained, all in accordance with local regulations and national laws, so that when they are retrieved and reviewed later, they can be traced to the originator.

In addition, a plot of the fire scene (e.g. a sketch of the scene or a floor plan with indications of fire damage and spread) should be prepared.

Plots or sketches of the scene should show:

- the area(s) of interest
- area of origin
- location(s) of potential ignition sources
- locations of items of evidential value
- direction of fire spread or explosion

For further details, see [Section 8.1.2 "Recording in Situ"](#).

5.7.3 Interpretation of Available Information

Information may be received from the first responder(s), or from others. It may inform the FI about what occurred prior to, or during the fire and may provide guidance regarding areas of greater or lesser 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. Verify whether the witnesses could have observed what they claim from their original vantage points.

5.7.4 Investigation Strategy

Fire scenes may involve buildings, motor vehicles (Duncan; 2021), ships, aircrafts or outdoor environments. However, the same general principles of fire investigation apply to almost all fires. In all investigations, there should be:

- an agreed and coordinated forensic strategy
- a safety protocol for working conditions

The FI should discuss with the investigating officer or customer and other relevant agencies how the intended course of action aligns with their overall forensic strategy and other requirements at the scene. If restrictions are placed upon the FI's examination as part of an overall forensic case strategy, then these must be recorded in the scene notes.

A forensic case strategy is an agreed action plan that shall include a demonstration of an understanding of the following (in no particular order of priority):

- a) What has happened in relation to the case?
- b) What is the investigating officer or customer's problem and request?
- c) Is the investigating officer or customer approaching their problem correctly from a scientific or forensic standpoint?
- d) What are the priorities of the investigating officer or customer?

- e) what are the potential scenarios (hypotheses) for the incident, and how can these be tested during the examination?
- f) What are the safety, practical, time and scientific limits for investigating the scene?
- g) Within the safety, practical, time, and scientific limits, what is the best way to help the investigating officer or customer solve their problem?
- h) What resources are available and how will these be deployed most effectively and efficiently?
- i) Is any other forensic or specialist expertise required?
- j) What are the responsibilities of all parties to the investigation?
- k) How will each stage of an investigation be prioritised given the investigating officer or customer's needs?
- l) What are the sampling requirements?
- m) What counter-contamination measures need to be put into place?
- n) Are additional tools or equipment needed and, if so, what additional processes or counter-contamination measures need to be implemented?

Each scene investigation must be carefully planned and carried out as soon as possible. Before entering, it is of extreme importance that one is fully aware of all the relevant, known circumstances relating to the fire. The FI should ensure that they are familiar with relevant tactical and background information gathered by the first responder(s), firefighters, etc.

If more information is required, this should be obtained before the start of the scene examination, where possible. This will help with successful planning of the investigation. Starting an examination without sufficient information may result in a sub-optimal investigation, and there is a risk of accidentally destroying evidence. See [Section 5.1 Figure 2](#) "Investigation Phases" and [Appendix B](#) "Investigation Strategy".

It is recommended that the investigation is carried out in teams, where possible. Depending on the nature of the scene, the teams can comprise different roles and number of people. Ensure that every team member is aware of their role (e.g. evidence collection, photography, etc.). See also [Section 4.1.1 "Allocation of Responsibilities"](#) and [Section 4.1.2 "Collegiate Approach"](#) for additional information.

It is recommended, although not essential, that at least two FIs be present at the scene to support each other and prevent a biased approach. Each FI must be comfortable with the type of investigation they are carrying out and must not hesitate to call for assistance, if necessary.

The fire scene investigation strategy should aim to facilitate answering the following points (Figure 5):

- establishment of the fire development – e.g. what and how?
- establishment of the origin of the fire – e.g. where and when?
- establishment of the fire cause – e.g. what and how?

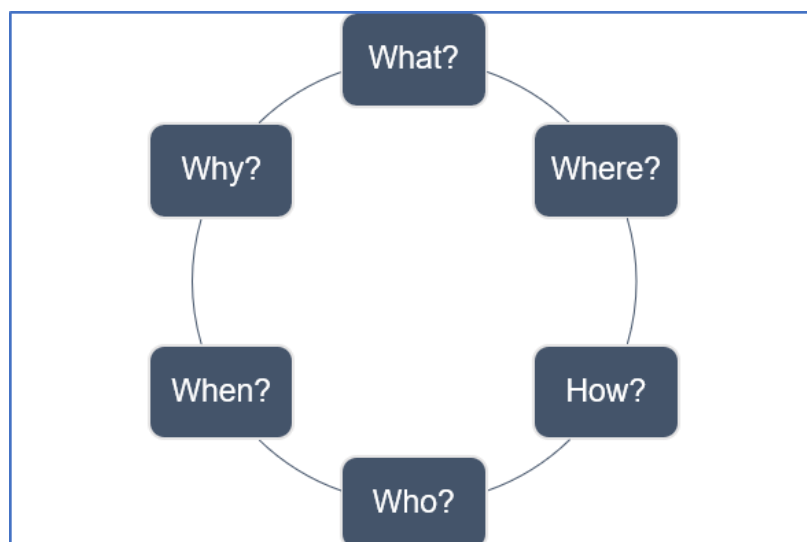


Figure 5. The 5 W1H.

The technical investigation focuses on the above but may also help the investigation determine the “who” and the “why” (e.g. equipment failure due to incorrect use).

5.7.5 Initial Overview

Where possible, try to gain access to a nearby building or use a fire service ladder or hydraulic platform or an aerial drone to observe the damaged building from a higher vantage point. It may help to see how the fire has spread and where it may have breached or vented through the roof.

Figure 6 below shows a general approach to fire scene investigation. If one suspects that an explosion has occurred, please also refer to [Appendix E](#) “Explosions Investigations”.



Figure 6. An illustration of a structured approach to scene investigation.

5.7.6 Surroundings

Outbuildings, garages, garden sheds, storerooms and cupboards should be checked for the presence of ignitable liquids and other relevant physical and trace evidence. If items of interest are found, such as petrol containers, other fuel bottles or cannisters, and matches or lighters, close to the property, they must be secured and seized according to recommended guidelines (see [Section 8 “Handling Items”](#) for further information). Consideration should be given to whether the ignitable liquids may be on site for routine or legitimate purposes.

5.7.7 Exterior

The exterior examination should be conducted systematically to identify evidence relevant to fire origin, fire development, fire spread, and the effects of environmental and operational factors. Investigators should inspect all external elevations and record the nature, extent, and distribution of fire damage.

The following considerations should be documented (in no particular order of priority):

- a) Which façade or external elevation exhibits the greatest degree of fire damage?
- b) What is the condition of the external walls, roof coverings, windows, doors, vents, and other exterior features?
- c) Are external surfaces covered by soot deposits, or is there evidence that soot has been removed or consumed by prolonged exposure to elevated temperatures? Investigators should recognise that soot deposits may be burned away under severe fire conditions.
- d) Are there external fire patterns associated with windows, doors, vents, or other openings? If so, what is their nature and extent?
- e) Is there evidence of fire venting from windows or other openings? Venting may produce characteristic flame damage, heat effects, or soot staining above and around the opening.
- f) Are there signs of external fire spread involving combustible cladding, roofing materials, eaves, fascia boards, vegetation, adjacent structures, vehicles, or other combustible items?
- g) Is there evidence that the fire originated externally and spread into the building, or originated internally and spread to the exterior?
- h) Have prevailing weather conditions, particularly wind direction and wind speed, influenced fire development or the observed fire patterns?
- i) How have ventilation conditions, building design, construction features, or structural openings affected fire spread and damage distribution?
- j) Have firefighting operations, including ventilation activities, water application, forced entry, or overhaul, altered the fire scene or influenced the observed fire patterns?
- k) Are the observed burn patterns, heat effects, and damage distribution consistent with the proposed area of origin and fire development scenario?

The FI should evaluate all exterior fire effects in conjunction with findings from the interior examination. Conclusions regarding fire origin and development should be based upon the totality of the available evidence and not solely on the appearance of exterior fire damage.

5.7.8 Interior, Fatalities and People

It is important to inspect all rooms, areas, and access routes, including those unaffected by fire, to identify and preserve information and evidence relevant to the investigation. Evidence that may assist in identifying the perpetrator can sometimes be located outside the scene or away from the area of greatest fire damage. Investigators should also consider whether there is evidence of another contemporaneous fire at a location separate from the suspected area of origin. During the interior examination, the FI should:

- inspect and document burn and smoke patterns
- assess the effects of the fire on walls, doors, ceilings, floors, contents, and other structural elements
- record variations in the type and degree of fire damage throughout the scene
- where injuries have occurred, document their locations and consider the circumstances and mechanisms by which they may have been sustained
- where fatalities are involved, record the location and orientation of the body and consider the factors that may have influenced its final position

These observations can provide valuable information regarding fire development (Ondrus, 1990), occupant movement, and the circumstances surrounding the incident. For more information on investigating fires with fatalities, please see [Appendix F](#) "Investigating Fire Scenes with Fatalities".

5.7.9 Glass Panes and Openings

Records of fire and soot damage to windows and their panes may inform on the course of fire development and ventilation effects. This may help determine the area of origin of the fire.

Inspect the broken glass from windows, including those which remain in the frame and those which are lying inside and outside the building. If necessary, excavate the fire debris below broken windows to locate fragments of glass from the broken panes. Pay attention to where these pieces of glass lie within the debris as their stratigraphy may inform on when a window was broken relative to the timing of the fire. Additionally, records of smoke deposition on both sides of the broken glass fragments may help determine whether a window was broken before, during, or after the fire. Furthermore, consideration of the fracture patterns or even reconstruction of the glazing may assist.

Consider whether a window was broken from the inside or outside. If it is suspected that it was broken from the outside prior to the start of the fire to gain access to the building, then consider requesting a crime scene investigator (CSI) to collect a sample of the broken glass for comparison, especially if a suspect has been identified and arrested.

5.7.10 Setting the Physical Boundaries of the Area of Investigation

The area or point of origin is the location where the fire is determined to have started. At the outset of an investigation, the entire fire-affected area should be treated as an area of interest. As the examination progresses and evidence is evaluated, this area may be progressively narrowed, for example to a particular room or section of a building. The final area or point of origin may vary in size depending on the extent of the fire damage, the complexity of the scene, and the ability of the investigator to interpret the available evidence.

Every fire investigation should have clearly defined physical boundaries. Any decision to include or exclude areas from the investigation must be documented, together with the rationale for that decision. Such determinations should be based on the interpretation of observed fire effects and patterns, supported by verified background information and relevant technical evidence.

5.8 Excavation

Determining the area or point of origin requires a systematic excavation of the area of interest. Depending on the extent of the fire damage, this area may initially encompass the entire room of origin. Excavation involves the careful and progressive removal of debris from structural elements, fixtures, fittings, and floor surfaces. As a general principle, excavation should proceed from areas of least damage towards areas of greatest damage. This process gradually exposes the area of origin and its contents, enabling evidence to be identified, documented, and interpreted. The method is analogous to archaeological excavation, where layers are examined in reverse order of deposition (Perrin *et al.*, 2014).

Several excavation methods may be used, depending on the investigation strategy and the circumstances of the scene. Factors influencing the chosen approach can include resource availability, time constraints, weather conditions, and the risk of scene deterioration. Common methods include:

- single context recording (see [Section 8 “Handling Items”](#)).
- stratigraphic excavation
- physical excavation techniques

These approaches draw on established archaeological principles and can be adapted effectively to fire scene examination. Figure 7 below is an example from an archaeological excavation where multiple contexts are illustrated from the pink lines. In this context, a *context* refers to a distinct stratigraphic layer and any associated artefacts, materials, or information contained within it. The FI is responsible for ensuring that excavation is conducted systematically and that stratigraphic layers are preserved and recorded accurately, avoiding both under-excavation and over-excavation.

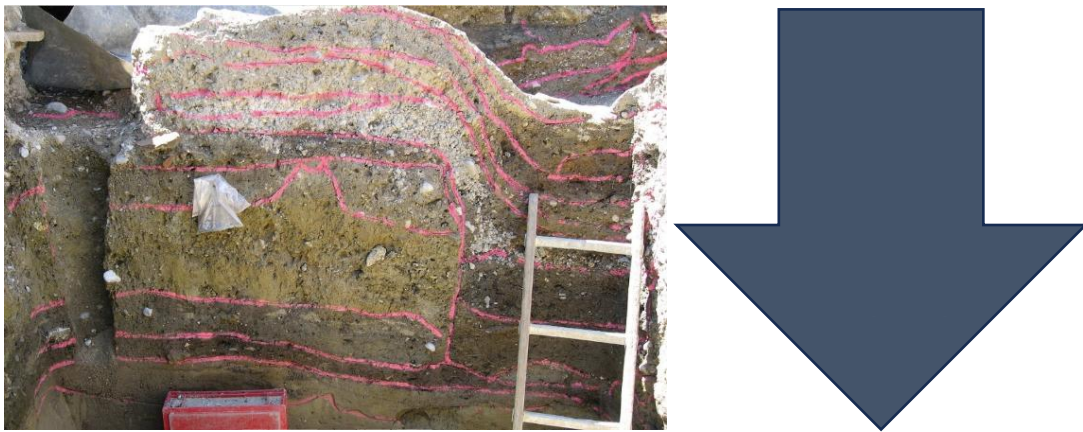


Figure 7. An illustration of 'contexts' (stratigraphy) from an archaeological excavation site.

5.8.1 Stratigraphic Excavation

Stratigraphy is a key concept in modern archaeological theory and practice. Modern excavation techniques (Perrin *et al.*, 2014) are based on stratigraphic principles, as applied to fire investigations. The principle of *original horizontality* holds that sediments are initially deposited in horizontal layers, while the principle of *layer continuity* states that these layers are deposited continuously.

Stratigraphic excavation involves examining layers (strata) in the reverse order of their deposition, beginning with the most recent layer and progressing to the oldest. This approach helps establish the sequence of events at a site by interpreting the relationships between layers and deposited materials.

In fire investigation, stratigraphic excavation is typically conducted through a systematic process of carefully removing and examining accumulated fire debris layer by layer. Excavation should begin at the perimeter of the affected area and progress towards the suspected area of origin, preserving and recording evidence as it is exposed. As a general principle, examination should proceed from areas of least damage to those of greatest damage. This method helps maintain the integrity of the evidence and supports a structured determination of the fire's origin and development.

5.8.2 Physical Methodology of Excavation

The excavation process can be carried out in various ways. At its most basic, it involves:

- working from the known to the unknown
- working from the top down
- using all available senses during the examination

Throughout the excavation, the FI should seek to establish the layout of the room of origin, including the locations of furniture, combustible contents, and other items of

interest. Where possible, the composition of furniture and combustible materials should also be determined. This information can assist in interpreting individual and collective burn patterns and may help refine the area or point of origin.

This stage of the examination may also reveal the presence of ignitable liquids or other distinctive odours that could provide valuable information about the fire and its development.

5.8.3 Mechanical Excavation and Organisation of Workforce

Various methods and equipment can be used to assist excavation, depending on the type, scale, and requirements of the scene. Mechanical excavators provide an efficient means of removing non-critical debris, such as collapsed roofing or wall materials, and can expose areas for more detailed examination by the FI. Manual excavation using a work team may also be appropriate. Before any personnel are permitted to assist with excavation, they should be briefed on:

- scene security and safety
- preservation of evidence
- excavation procedures and techniques

Whether using mechanical equipment, a work team, or both, the FI should develop and implement a clear excavation strategy. Where others participate in the excavation process, the FI must closely supervise all activities to ensure that evidence is preserved and recovered appropriately.

6. VALIDATION AND ESTIMATION OF UNCERTAINTY OF MEASUREMENT

6.1 Validation

The validation of the fire scene investigation process is heavily dependent on (1) the 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 FI must be appropriately qualified and competent. Their training must be documented and assessed, and they must undertake continuous professional development and maintain and demonstrate their skills and competency, e.g. by keeping up to date with latest developments in the field (e.g. Evans, 2023).

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), through reference to professional and peer-reviewed literature, manufacturers' specifications, or by in-house methods.

The investigative techniques (for example, the recognition and interpretation of burn patterns) used in fire scene investigation can be validated using known ground truth data, published literature and experimental 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.

Any scientific method should be repeatable, and the results obtained from it are objective, reproducible and robust, regardless of the personnel conducting the examination, analysis or investigation. The validation of a scene examination method should therefore attempt to investigate and verify the following:

- ground truth data
- repeatability of the method
- reproducibility of the results
- bias
- uncertainty of measurement
- competency of the practitioner

Each of the above criteria is very much interconnected. The ground truth data is rooted in the science and chemistry of fire and affects all the other elements. Reproducibility and repeatability, when it comes to a scene investigation procedure, stem from the combination of how detailed and comprehensive the documented investigation procedure is and how consistently a practitioner applies it. Cognitive bias (including confirmational bias), competence, and decision-making then further feed into any variability in the uncertainty of measurement (Almirall et al., 2017) and, therefore, the overall results and conclusions of a scene investigation (See Figure 8).

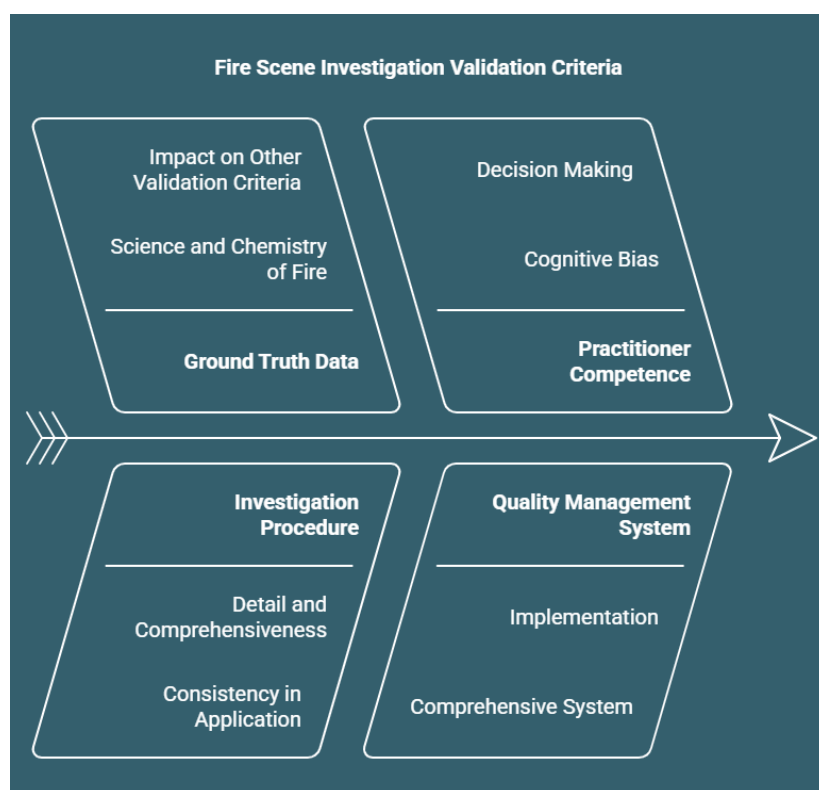


Figure 8. Overview of some of the validation criteria in fire scene investigation.

There are essentially three main pillars in the validation and verification of a fire/crime scene investigation procedure/methodology (see Figure 9):

- ground truth data
- comprehensiveness of the investigation procedure and the quality management system
- the competence of the practitioner

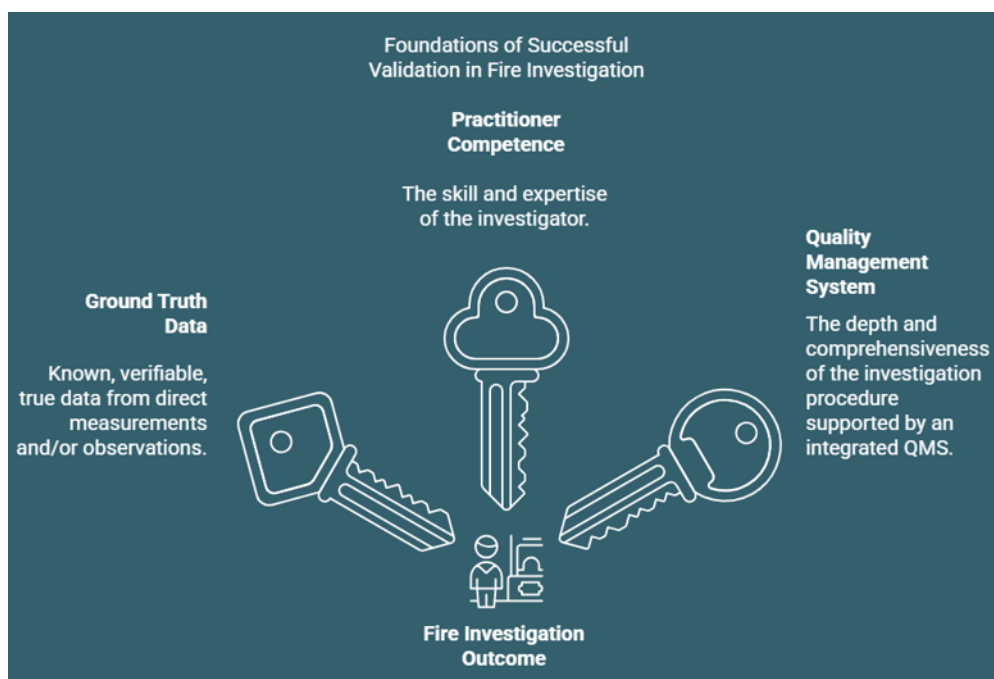


Figure 9. Foundations of successful validation in fire scene investigation.

Any validation (and verification) exercise will need to compile sufficient objective evidence demonstrating that each of the above criteria has been suitably addressed, such that the validation expectations are met.

The practitioner's organisation should document a validation and verification procedure that details validation planning, testing and sign-off, as well as guidance on assessing the main sources of uncertainty.

Additionally, the practitioner's organisation should document a reporting procedure that guides the reporting of uncertainty of measurement in fire investigations.

Participation in and results from any form of proficiency testing or collaborative exercises will contribute to a body of objective evidence for the purpose of validating and verifying a scene investigation/examination procedure.

6.2 Estimation of uncertainty of measurement

The fire investigation outcome depends on the FI's knowledge and skill set, as detailed in [Section 4.1](#).

The uncertainty of measurement may be broken down into two components:

- evaluation of the origin of the fire (area of origin vs. point of origin; the more the FI wishes to pinpoint the exact location of the origin, the higher the likelihood of error)
- evaluation of the cause(s) of the fire (predicated on the correct determination of the area of origin)

Uncertainties in the entire fire scene investigation process may arise from several sources and contribute to variations in the evaluation of origin and cause. These factors may include (but 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

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

7. QUALITY ASSURANCE

The practitioner's organisation should have a documented quality policy and manual, the latter of which should provide an overview of how any aspect of its work, including, in this case, fire investigation, contributes to the overall quality of its work. This may include personnel training and competence, as well as participation in proficiency tests and collaborative exercises.

7.1 Proficiency Testing / Collaborative Exercises

There are rarely any external proficiency tests (PTs) available for fire scene investigation. However, there is nothing to prevent an organisation from implementing its own proficiency tests internally. FIs are advised that they should take part in a relevant collaborative exercise (CE) or PT for fire scene examination periodically so that their competence can be demonstrated and assessed. Such exercises and tests can be internal or external to the practitioner's organisation.

See QCC-FWK-004 "Framework for the conduct of proficiency tests and collaborative exercises within ENFSI" for more information ([CQQ-FWK-004-PT-CE.pdf](#)). The document provides the ENFSI Expert Working Groups (EWGs) with guidance on organising effective PTs and CEs for their members.

While CEs and PTs are usually undertaken by a single representative or an organisation. Due to their rarity, it is recommended that organisations should facilitate as many of their practitioners as possible to participate in these tests/exercises. The organisation should document a schedule in anticipation of these tests/exercises such that all their practitioners are tested within a defined cycle. It is recommended that an organisation should document a PT and CE procedure.

7.2 Quality Controls

Quality control (QC) is a critical component of fire and explosion scene investigation, providing assurance that investigative activities are conducted consistently, competently, and in accordance with established scientific and quality management principles. In the forensic context, QC focuses on the operational checks and measures applied throughout an investigation to verify that evidence is identified, recovered, recorded, preserved, and interpreted correctly. Effective QC reduces the risk of errors, contamination, loss of evidence, inconsistent practices, and incorrect conclusions regarding the origin, cause, or development of a fire or explosion. It also supports compliance with ISO/IEC 17020, ISO/IEC 17025, and the forensic science principles outlined within ISO 21043, ensuring the integrity and reliability of investigative findings.

During fire and explosion investigations, QC should be integrated into every stage of the process. Practical measures include the use of scene examination checklists, peer review of scene strategies and origin-and-cause hypotheses, verification of critical decisions by a competent second investigator, and routine supervisory review of records, sketches, photographs, and evidential recovery logs. Investigators should ensure that scene notes are contemporaneous, complete, and capable of supporting

the rationale for decisions made during the examination. Sampling strategies should be documented and justified, particularly where ignitable liquid residues, explosives residues, or other trace evidence are recovered. Equipment used for scene examination and sampling should be subject to routine inspection, maintenance, and calibration where appropriate, with records retained as part of the quality management system.

A robust QC programme should also include regular audits of investigation files, technical reviews of reports before issue, competency assessments, proficiency testing, and monitoring of non-conformities, complaints, and near-miss events. Where significant findings are reached, such as the determination of a fire's area of origin or the identification of an ignition source, independent technical review should be considered to verify that conclusions are supported by the available evidence and that alternative hypotheses have been appropriately evaluated. Contamination prevention measures should be routinely monitored through compliance checks, equipment cleaning records, scene access controls, and continuity reviews to ensure the integrity of recovered evidence.

Importantly, quality control should not be viewed solely as a compliance activity but as a mechanism for continual improvement. Trends identified through audits, case reviews, corrective actions, and lessons learned should be analysed to identify recurring risks and opportunities for improvement. By implementing structured QC processes, maintaining effective oversight, and promoting a culture of critical review and scientific objectivity, fire and explosion investigation organisations can enhance the reliability, reproducibility, and defensibility of their findings while maintaining confidence in the forensic process.

7.3 Data Collection for control, monitoring and trend analysis

Effective data collection is essential for maintaining control of the fire and explosion investigation process and for supporting evidence-based quality management. In addition to case-specific records, organisations should systematically collect quality and performance data relating to scene examinations, evidence recovery, contamination incidents, technical reviews, non-conformities, corrective actions, audit findings, training outcomes, and competency assessments. The purpose of collecting such data is not only to demonstrate compliance with quality requirements but also to provide objective evidence of process effectiveness and identify areas where controls may require strengthening.

Analysis of this information enables organisations to monitor performance over time and identify recurring issues, emerging risks, or opportunities for improvement. For example, trend analysis may reveal repeated deficiencies in scene documentation, common causes of evidence handling errors, recurring contamination events, or training needs linked to specific investigative activities. Data from peer reviews, technical reviews, customer feedback, proficiency testing, and management reviews can also provide valuable indicators of investigation quality and consistency. By using defined quality metrics and regularly reviewing trends, fire and explosion investigation teams can make informed decisions, target resources effectively, and implement preventive actions before isolated issues develop into systemic problems.

A structured approach to data collection and analysis supports continual improvement and aligns with the principles of ISO/IEC 17020, ISO/IEC 17025, and ISO 21043. Importantly, the focus should not be solely on identifying failures but also on recognising positive performance and effective practices that can be shared across the organisation. When combined with risk management and quality control activities, trend analysis provides a powerful mechanism for enhancing investigative reliability,

improving operational resilience, and maintaining confidence in the scientific integrity of fire and explosion investigations.

7.4 Verification / Peer Review

Peer review of reports (Daubert standards) is an essential process that forms part of a robust scientific investigation and its quality assurance and control (Fournier, 2016). It is mandatory in some jurisdictions. It is strongly recommended that reports be critically reviewed by someone who has been formally authorised to undertake such reviews 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.

Commonly, after completing the fire scene examination the FI must review their findings with an authorised fire scene reviewer/checker. The FI must ensure that adequate scene examination records are available for an effective debrief of the scene investigation and its findings. The FI should use their scene examination records to describe their investigation to the reviewer/checker who will confirm whether the examination was carried out safely and in accordance with the organisation's documented fire investigation procedure. The FI should present the information in a chronological order in the way that they received it, so as not to unduly influence the reviewer's thought process. The reviewer/checker will test the FI's objectivity, logic, and conclusions, as well as any other reasonable alternative hypotheses, using the available information. In summary, the reviewer/checker should review the following aspects of an investigation (in particular order of priority):

- a) Whether the FI had followed the organisation's documented fire investigation procedure?
- b) Whether the FI had made sufficient examination records of the scene?
- c) All critical findings, including the fire's origin, potential ignition sources, whether the correct samples were recovered, and whether all pertinent information were retrieved or requested. A critical finding is one that makes a significant contribution to the case's evidence and either cannot be confirmed later or maybe subject to possible differences in interpretation among scientists.
- d) Have the requirements of the investigating authority or customer been met?
- e) Have the appropriate questions been asked and answered as far as is possible?
- f) Is the investigation balanced and impartial?
- g) Is the interpretation of the findings balanced, soundly based and supported by evidence that is documented in the case file?
- h) Are the findings clear, accurate and unambiguous?

No final reports should be released until a debrief has been carried out. If exhibits were retrieved from the scene and it is known that the investigating authority or customer will require tests or laboratory examinations of those exhibits, the reviewer/checker should discuss the forensic strategy to be adopted for those exhibits with the FI. The practitioner's organisation should document the peer review process, describe which observations and findings must be reviewed, and specify how a review should be recorded. It is recommended that, as a minimum, all critical findings must be reviewed.

8. HANDLING ITEMS

8.1 At the scene

8.1.1 Dialogue with the First Responder / Attendee

The general recommendation once the fire has been extinguished is to preserve the scene, and thereby, the evidence for the FI. Upon arrival at the scene, the FI should

liaise with the first responder to determine whether any potential evidence has been removed, altered or preserved prior to their arrival. Any changes to the fire scene that occurred before the FI's arrival should be noted by the FI, and their impact should be considered. It is important that any further investigation record the following activities, including (but are not limited to):

- breaking of doors and/or windows
- general and targeted fire-fighting activities

8.1.2 Recording In Situ

As part of the initial examination the scene should be recorded before any work is carried out. Documentation of the exterior of the scene may be relevant and could include landmarks 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. Drone footage is particularly helpful over large external areas.

The recording of the scene can be undertaken using several formats, including, but not limited to, a series of general photographs and/or videos, VR (Yu et al., 2023) or LiDAR scanning (Kottner, Thali and Gascho, 2023), 360° photography, aerial drone footage, 3-D recording (e.g. Gaussian splatting) and other scanning techniques, and thermal imaging. More specialist techniques, for example, IR and UV light sources, may also be utilised. Even rooms that are less severely damaged by fire or have no fire damage at all should be documented.

Practitioners recording the scene using technology must be trained and competent in the use of the equipment and be aware of local regulations and national laws regarding file processing, accessibility, transfer, storage and retention. In addition, diagrams of the fire scene should be prepared by the FI, and these can take several formats.

It should be noted that any imaging technique must have scientific validity and be generally accepted as capable of producing accurate and reliable representations of the scene. Images should be captured in RAW format.

The recording process must not negatively impact the recovery of forensic evidence at a later point, and precautions must be taken to ensure this. Forensic evidence may need to be protected and recorded (prior to any interpretation and subsequent removal). The impact on forensic evidence, such as fingermarks, glass, tool marks, footwear/tire marks, fibers, blood (including blood patterns), DNA, etc., must be considered.

All images taken can be recorded in a log and/or diagram, detailing the unique number for each image or file, 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 they can be retrieved later and traced to the originator, in accordance with local regulations and national laws.

Each investigator is free to document in the manner most appropriate to the situation and the available resources. This can be, for example, taking notes on paper and pen, digitally, or by audio means. When sketching the fire scene, alternatives to paper and pen include digital documentation such as LiDAR scanning, still photos, and more.

8.1.3 Sampling

Coordinate and document all activities relating to sampling at the fire or explosion scene as required (Horswell, 2004). All work should be carried out in accordance with the appropriate best-practice manuals and guidelines. When investigating the cause of

a fire, bear in mind that subsequent forensic investigations may also be needed, for example, the recovery of digital data, physical and biological traces, such as ignitable liquids, fingerprints, fibers, and blood, etc.

For specific packaging requirements, refer to the appropriate and current recommendations in the FI's own jurisdiction. A certified specialist will most likely examine or analyse any recovered sample. A certified specialist is a practitioner who is accepted by their organisation and/or the wider peer community to be an expert in their profession.

When the test item is likely to be examined for more than one evidence type, it is imperative that the requirements of all the relevant evidence types are considered when deciding on the method of packaging and type of packaging material to use. Some evidence types require different, and even conflicting, packaging: for example, items that require DNA recovery generally need to be sampled into breathable packaging, whereas items for ignitable liquid analyses need to be in airtight packaging. If there is any doubt, the FI is encouraged to contact the appropriate forensic specialists before sampling.

Items of interest, e.g. matches, cigarette butts, candle wicks, night-light (tea light) candle holders, wick holders, electrical items, etc. in the area of origin may be of significance when the cause of fire is to be determined by hypothesis testing. It may be necessary to recover such items, as appropriate. It may also be necessary to obtain additional items, such as bedding or furniture, for further examination or testing.

When recovering a sample, the nature of the sample should be adequately described and recorded. Samples must not be destroyed without prior authorisation from the appropriate agency or party as they may be required for further examination.

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, from:

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

The FI is duty-bound to consider the possible health risks posed by inhaling certain chemicals and must always wear proper respiratory protective equipment. Despite this, throughout the investigation, the FI should be wary of any strange smells, e.g. from possible ignitable liquids. This is especially important when dealing with materials that can absorb liquids, such as cloths, carpets, paper, and wood.

Hydrocarbon detection dogs, electronic sniffer devices or alternative light sources can be used to help search for ignitable liquids. The results from these cannot confirm the presence of an ignitable liquid, but they can assist in identifying suitable sampling locations.

Confirmation of the presence of an ignitable liquid requires laboratory analysis. When taking samples at a scene, it may be appropriate to take a reference sample. Some materials, such as different kinds of plastic foams, rubber mats, and inks, can contain

chemicals that are also found in some ignitable liquids. As such, recovered samples may yield results that need to be compared with a suitable reference sample to aid interpretation. When taking reference samples, or indeed any sample, the FI must ensure that their outer gloves are changed to prevent cross-contamination from previous samples.

It is recommended that samples should be collected or exhibited in the following sequence to minimise any potential risk of cross-contamination during the sample recovery process: (i) control packaging, (ii) reference substrate, (iii) fire debris, (iv) reference liquid.

The samples must be placed in suitable separate packaging, as appropriate for the laboratory/country. A control sample of packaging should be provided with the test samples. Cross contamination must be avoided between sample recovery by changing gloves or use of disposable tools when possible. Gloves and tools, both of which can be in direct contact with materials at the origin of the fire, must be shown to be free from ignitable liquids or other substances that could interfere with analyses, before use. It is recommended that disposable gloves be used (and changed as necessary); these may be worn over safety-type gloves.

Furthermore, the FI should be aware of any other potential sources of contamination, e.g. petrol-driven machines that may have leaked fuel, or additives that may have been used in some extinguishing foam or water. For the same reason care should be taken if petrol-driven electricity generator is used at the scene. The generator should not be filled with petrol at the scene and preferably not by someone attending the scene. The generator should be removed from the scene, filled with petrol (keeping the fuel out of the scene) and then returned to its position.

The contents of bottles and cans (and other 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 ignitable liquid (or vapour) may remain in it. Containers can also have fingerprints or DNA which may need to be recovered during laboratory examination.

If the container is sealed and not leaking, it should be packaged appropriately without any changes.

Sampling or decanting of liquid must be carried out away from the area of interest to avoid potential contamination.

If the container is leaking or has no lid, the liquid must be decanted into a sealable container. If the container contains a small sample of the liquid to be taken, use a clean pipette rather than pouring it out of the container. If the container is a drinks bottle, decanting the liquid can remove DNA from the mouthpiece so it may be pertinent to have DNA samples taken before this. (This needs to be done by a trained and competent person).

In all circumstances, fingerprints on the container must be preserved. Fingerprints can be removed or damaged through handling. Again, advice from a specialist may be needed, but at a minimum, the container should not be handled unnecessarily or without gloves.

8.1.4 Technical Systems

A relevant specialist should attend the scene and carry out examinations of technical systems. However, if this is not possible then advice must be sought.

The FI should consider that evidence can be recovered from security and smart devices used in properties and vehicles. While the FI may not have the expertise to recover or interpret this evidence, they must endeavour to ensure the item is protected and recovered. The FI should also ensure that any device they carry (mobile phone, laptop, etc.) will not interfere with any local network or device.

As most security systems record remotely (to the owner's phone or computer), the FI should be aware where fire damage is not extensive, that the device may continue video streaming or recording during their attendance.

Furthermore, there are several inconspicuous devices, such as table lamps, clocks, and air fresheners, that also contain recording capabilities, some of which record to an SD card and others to a remote device.

During the investigation, the FI should document the positions of items which are particularly badly damaged by the fire. It may be beneficial (or necessary) to remove these items, along with part of whatever they are attached to (e.g. wall panels). Ensure the following:

- record 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 buttons, knobs, dials or switches

There may be relevant, retrievable information from any device recovered, whether fire-damaged or not, though this is likely to be achieved after the fire investigation. If the information is later found to be relevant to the fire investigation, the FI should consider those findings.

8.1.5 Fatalities

Early consideration must be given to whether a Forensic Anthropologist is required in the excavation of the scene and body recovery if the body is damaged.

If the body and surroundings are not completely burned or charred, evidence may remain on, beneath or near the body, in the clothes, or in nearby items, which can provide valuable information about what happened before the fire.

Before any change to the scene or the taking of any samples, the body must be recorded in situ. The final position of the body relative to the surroundings and the condition of the body should be recorded.

Document any damage to the body and clothing. Any possible pre- or post-burn injuries should be noted as well as the areas on the body that are burned or have smoke deposits thereon. Further documentation is needed during the recovery process particularly when the body is turned.

If an ignitable liquid is suspected to have been used to deliberately increase the rate of growth and the extent of the fire, then samples must be taken. To best preserve such evidence, the deceased's clothes must be recovered if possible. Additionally, materials beneath the body should be seized separately, e.g. bedding, seat cushions, carpets, flooring, soil, vegetation, etc.

Unless clothing is loose and likely to fall off, it should remain on the body. Any attempt to remove the fabric may rip skin or tissue and affect the subsequent post-mortem examination. If samples of the clothing are needed for laboratory analysis but cannot be removed at the scene, ensure that the pathologist or other specialist is informed of

the sampling requirements. Sample recovery could be wide-ranging in scope, including biological and physical traces, such as DNA, fibers, paint, GSR, glass, ignitable liquid residues; therefore, the sample recovery methods may vary.

The pathologist should be informed of any changes to the state of the body or items removals.

8.1.6 People of interest (witnesses, suspects, accused)

The FI may provide advice on potential evidence recovery and packaging from a living person of interest (e.g. a witness, suspect, or accused).

Visible fire remains, which may be on a suspect's clothing or footwear, should be secured by carefully removing them. Clothing and footwear may need to be inspected under a microscope to determine whether they have been subjected to flame washing (also known as flashburning) or high temperatures (Leung and Halliday, 2010). The entire garment must be taken whole, wherever possible.

Clothing and footwear that are taken must be packaged appropriately, as soon as possible, to preserve any biological or physical trace evidence including, but not limited to, ignitable liquid traces as soon as possible. Hand sampling, if required, can be performed using the identified method in the FI's country, such as placing the hands in airtight bags for a set duration and using suitable gloves or absorbent material. The sampling is to be done as quickly as possible (Watterson, Blackmore and Bagby, 2006). It is recommended that the sampling procedure is discussed with a specialist beforehand.

A medical examiner / pathologist should inspect the person of interest as soon as possible to see if there are burns to skin, hand hair, eyebrows, 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.

8.1.7 Documents

If documents (or banknotes) are found during a fire investigation, consider whether they need to be secured for subsequent examination. The documents or money should be photographed in situ and carefully packaged.

Several different evidence types can be recovered from documents, e.g. DNA, fingerprints. Documents may also be examined for indented impressions and handwriting/signature comparison.

Depending on what evidence is considered relevant, this will impact on how the documents are packaged, so it is worth contacting a specialist beforehand. In general, the documents should be placed between stiff sheets of cardboard and packaged in a rigid box (a photograph box is suitable). If large quantities have been recovered, they can be packaged as found in a sufficiently large box, ensuring the material is secured in the box to preserve its integrity during transport.

If the item is damp and/or the pages are burnt on top with unburnt pages underneath, do not attempt to separate them at the scene; package them as a single unit. Damp material must be sent for investigation as soon as possible, with the receiving specialist being notified of this information.

8.1.8 Spontaneous Combustion

When spontaneous combustion (Gray, 2008) is suspected as the cause of the fire, samples should be collected from the area or point of origin and from less-damaged areas. There may also be relevant materials (e.g. linseed oil) stored nearby which

should be considered as possible reference samples. If they are considered relevant, they should be seized as samples, as their chemical compositions may vary depending on the manufacturer.

Fire debris samples from the area of origin and from the less-damaged areas should be taken before the handling and recovery of any reference samples (Borusiewicz, 2002; Stauffer, Dolan and Newman, 2007; Buc et al., 2008). In all instances, counter-contamination procedures should be adopted, including but not limited to, glove changes between samplings.

It should be noted that some self-combusting materials are unstable and need specialist storage. Consult with a specialist if required.

8.1.9 Packaging/ Removal of Fragile Items or Items Likely to be Damaged

If items need to be removed from the scene immediately or are likely to become damaged, they should be photographed in situ and documented appropriately. The location of the item in the building, vehicle or area from which it was taken should be clearly documented. 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 previously. Any deviation from this approach should be recorded, e.g. when items are recovered under challenging circumstances or environmental conditions. The rationale for adopting a non-standard approach should be recorded.

Once recovered, 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 an appropriate team member of the investigation, if applicable.

8.1.10 Maintenance of Sampling Equipment

Each organisation should have a policy and a procedure detailing how equipment is managed and used at a scene. Such policies and procedures should align with international standards, e.g. ISO 21043, and national guidelines where available.

The procedure should cover the type of equipment and any permitted variations, how the equipment should be used and by whom, how the equipment is cleaned (if appropriate), and any testing required before or after use.

The maintenance of the equipment used for sampling should also be documented, outlining any regular maintenance required and who is responsible for carrying it out.

Data records for the equipment's use and maintenance should be stored and retained for a specified period that is required by the local jurisdiction so that it is available for inspection if necessary.

Some equipment may require calibration and testing before use at the scene (e.g. a multimeter or electronic sniffer device), and there should be traceability of this process.

The manufacturer of each piece of equipment may be able to provide details on the lifetime of their product(s) and, if applicable, recommend cleaning schedules.

8.2 In the laboratory

Subsequent laboratory work by specialists may impact on the outcome of the fire investigation.

Where appropriate, the FI should be present and may participate in the examination of articles sampled or seized during the fire scene examination. An example of this may be the examination of an appliance using microscopy or electrical testing equipment.

Where this is not relevant or possible, for example when ignitable liquid analyses are undertaken, the FI should seek access to the relevant analysis report.

9. INITIAL ASSESSMENT

9.1 Determining the area or point of origin

The area or point of origin is the location where the fire is considered to have originated. One of the methods used to determine an area or point of origin is to recognise, identify, analyse and interpret different fire patterns (Almirall and Furton, 2004; Hine, 2004; Gorbett *et al.*, 2015; Icove and Haynes, 2017; Lentini, 2019).

The FI must attempt to assess the fire damage and locate the area or point of origin using the patterns of damage unveiled by excavation and reconstruction. Consideration should be given to:

- areas of differential fire damage, from least to most damage, and the overall fire patterns
- directions of fire spread
- using appropriate methods, e.g. sequential pattern analysis, heat and flame vector diagrams, arc mapping (Icove *et al.*, 2021), etc., where necessary
- effects of fire on various structural components and contents of the structure, and compare like-with-like
- location of the lowest level of burning
- possibility of multiple areas or points of origin
- presence or absence of ignitable liquid odours
- conditions and states of doors and windows
- ventilation at the time of fire or explosion
- potential ignition source(s) within or in the vicinity of the area of origin
- additionally, for gas explosions:
 - directional damage to structural elements
 - evidence of gas leakage

It is desirable that some indication of the level of certainty for the area(s) or points(s) of origin should be recorded.

9.2 Determining the potential causes of the fire

The FI should endeavour to determine the cause of the fire or explosion by identifying the ignition source, using the recovered evidence and the available information. To establish the cause of a fire, the FI would normally have already determined a point or area of origin. Document all possible objects within the previously identified point or area of origin that could have caused the fire. Search in the area of origin and its immediate vicinity for evidence of any remnants of potential ignition sources, such as (this is not an exhaustive list):

- matches, candles, lighters or blowtorch
- cigarettes or other smoking paraphernalia
- incense burners
- electrical equipment and their component parts
- incendiary devices
- fireworks

- hot-working equipment (e.g. welding tool)
- mechanical equipment (e.g. cutting tool)

There may be other ignition sources that the FI might consider or identify at a scene.

Where an examination of the fixed electrical installations is an appropriate course of action, the conditions of the mains electricity intake, electricity meter and consumer unit (fuse box) must be noted. The positions of all circuit breakers must also be recorded.

When considering the possibility of an electrical source of ignition, it may be necessary for the FI to conduct a preliminary examination of questioned electrical appliances at the scene. Where this is an appropriate course of action, the following information with respect to each appliance must be documented, if possible:

- the location of the appliance in relation to the area of origin
- whether the appliance was connected to a mains supply, i.e. a socket outlet
- the position of the appliance's power switch
- the position of the socket switch (if there was one)
- the position and integrity of any inter-connecting adaptors or electrical cords, such as multi-way adaptors and extension cables, between the questioned appliance and the socket outlet; the position of any power switches on the multi-way adaptor
- where appropriate, the integrity (resistance) of cartridge fuses inside the power plug of questioned appliance can be tested using a multi-meter

After this preliminary examination, the questioned appliances should be returned to the state in which they were found. As far as possible, the questioned appliances, including all their component parts, electrical cords and plugs, must be recovered and submitted to the laboratory for detailed examination by the FI or a specialist.

If necessary, call appropriate specialists for assistance or send the recovered items of interest to them for further examination. If items are to be examined by specialists, it is beneficial for the items to remain in the same condition as when they were discovered. Please refer to [Appendix J](#) "Examples of Fire Causes" for additional information.

10. PRIORITISATION AND SEQUENCE OF EXAMINATIONS

10.1 Safety Assessment

Health and safety must always come first (see [Section 14](#) "Health and Safety" and [Appendix C](#) on PPE for additional information). Avoid unnecessary risks, use appropriate protective equipment, and be aware that floors, walls, chimneys, and beams may collapse. Some structures may need to be secured before work begins.

10.2 Orientation and Investigation Planning

Before an investigation begins, an investigation strategy (see [Appendix B](#) for further information) should be developed to clarify the following:

- the client's specific information needs and priorities
- any additional forensic investigations that may be required
- which investigations or evidence types are likely to deliver the greatest value to the client
- the potential value of the information each investigation can provide

10.3 Key Prioritization Factors

- a) Process perishable or fragile evidence first, such as biological materials (see also [Section 8](#) “Handling Items” for additional information).
- b) Prioritise elements most relevant to the investigative and legal objectives.
- c) Consider environmental conditions, such as weather, when sequencing forensic procedures.

10.4 Investigation Sequence

- a) Conduct non-destructive techniques and investigations before excavation.
- b) Coordinate laboratory analyses after fieldwork to avoid backlogs.

See also [Section 5 “Methods”](#) and [Appendix B “Investigation Strategy”](#) for further details.

11. RECONSTRUCTION

Forensic reconstruction can deliver additional value to an investigation. It may provide insight into how traces (evidence) are donated or created (activity-oriented) or allow an assessment of probabilities of how or where an activity occurred. The results of a reconstruction can therefore influence the interpretation and the strength (value) of the conclusions drawn from the evidence. Reconstruction may entail the physical reconstruction of a scene, the reconstruction of events (activities) through verification of information, and fire tests under controlled conditions.

The type of reconstruction required may necessarily dictate the level of detail and amount of information to be recorded. Information to be recorded when carrying out a reconstruction might include details of the investigators involved, the setup of the reconstruction, all technical aspects, all factors that may influence the results, and the reconstruction process (the latter should be recorded by photography and video), etc. A well-documented reconstruction allows, if needed, for a professional review afterwards.

11.1 Reconstruction of a Fire Scene

After the excavation is complete, the area should be photographed. Items found or displaced from the area can then be returned to their original positions, if possible. The reconstruction can be aided by features such as aligning corresponding protected marks between the floor and walls and objects, such as items of furniture, that have stood on or against those surfaces (Icove, Dehaan and Haynes; 2013).

When all the items have been returned to their original positions that they occupied at the start of the fire, their fire damage can be compared, firstly like-with-like, and then to other patterns of burning within the room, including those on the floor, ceiling, and walls. This reconstruction must be compared with the owner’s sketch of the area, if available.

However, be mindful that an owner’s recollection or description of the room layout may be incorrect or misleading. When reconstruction of the scene is complete, the investigator can continue with their interpretation of the fire patterns. The reconstructed scene will provide clearer overall fire patterns that can then be evaluated for origin and cause determination (Almirall and Furton, 2004; Hine, 2004; Gorbett *et al.*, 2015; Icove and Haynes, 2017; Lentini, 2019).

Accurate documentation of the reconstruction is essential. Photograph and video the excavated area, both with and without the repositioned items in place. Prepare a plot or sketch of the room(s), include the furniture and any other notable items.

It is often helpful to see a similar house or object that has not been damaged by fire.

11.2 Fire Tests/Experiments

The FI may carry out fire experiments in situ at the scene, in the laboratory, or at sites suitable for larger-scale testing (Adolfson, 2015). When conducting scientific fire experiments in a laboratory, it is recommended to use a suitable test and to document the methodology clearly.

There are several reasons for carrying out fire experiments. As mentioned earlier in the BPM, an experiment is one way to test a hypothesis. It can test and investigate the viability of potential causes of a fire under certain given conditions and help parties to the investigation visualise the fire's development. As far as practicable, experiments should be conducted under the same general conditions as at the time of the original fire (e.g. ambient temperature and, if outdoors, weather conditions). All fire tests should be video recorded and documented in detail.

There are two main categories of fire experiments:

- a) Single parameter/variable - The purpose of this is to gain specific knowledge related to one parameter/variable, e.g. how a naked flame will affect a specific item or material, such as a piece of curtain.
- b) Multi-parameter/variable - The purpose of this is to test several parameters/variables. These may include, for example, the source of ignition, fabric of the curtain (such as weight per square meter, thickness, etc.), and so on.

Factors to consider when setting up fire experiments may include, but are not limited to:

- geometry between ignition source and fuel
- ventilation
- identifying suitable parameters
- choice of methods
- repeated experiments
- consistency of results
- structure of the documentation and quality control
- limitations of experiments
- uncertainty of measurement

12. ASSESSMENT OF RESULTS AND INTERPRETATION

12.1 Analysis and hypothesis

12.1.1 Develop hypothesis (or hypotheses)

Based on the empirical data obtained during the investigation, the Fire Investigator (FI) should develop an initial hypothesis, or a set of competing hypotheses, to explain the fire's origin, cause, development, and spread. The formulation of hypotheses is a fundamental component of the scientific method and provides the framework through which the available evidence can be evaluated and interpreted. A hypothesis shall be based on observable facts (e.g. fire patterns), physical evidence (e.g. presence of a viable ignition sources), information from technical systems and reliable witnesses, analytical findings, and established scientific

principles (e.g. fire dynamics) (Qunitiere, 2006; Drysdale, 2011; Qunitiere, 2016; Gorbett, Pharr and Rockwell, 2021). It should provide a logical and scientifically plausible explanation for the circumstances of the incident.

To be scientifically valid, a hypothesis shall be both **testable** and **falsifiable**:

- A hypothesis is **testable** if evidence can be obtained and evaluated to determine whether the hypothesis is consistent with the observed facts and circumstances.
- A hypothesis is **falsifiable** if evidence can be obtained that demonstrates the hypothesis is incorrect or inconsistent with the available facts.

A hypothesis that cannot be tested or disproved does not satisfy the requirements of the scientific method and should not be relied upon as the basis for investigative conclusions.

The FI should, where appropriate, develop multiple reasonable hypotheses and avoid prematurely focusing on a single explanation. Alternative explanations should be considered throughout the investigation and evaluated objectively against the available evidence. As additional information is obtained, hypotheses may be refined, combined, rejected, or replaced.

Examples of hypotheses may include:

- the fire originated in the kitchen and was caused by unattended cooking
- the fire originated within an electrical appliance due to an electrical fault
- the fire resulted from the ignition of combustible materials by a discarded smoking material
- the fire was initiated through the deliberate application of an external ignition source
- the fire originated externally and subsequently spread into the structure

The purpose of hypothesis development is not to prove a particular cause, but to establish scientifically reasonable explanations that can be rigorously evaluated through hypothesis testing. The subsequent investigation should seek evidence that both supports and challenges each hypothesis until the explanation most consistent with the available evidence and scientific principles is identified.

12.1.2 Divergent and Convergent Thinking in Hypothesis Development

The development of reasonable hypotheses should involve both **divergent thinking** and **convergent thinking** as part of a structured scientific approach to fire investigation.

Divergent thinking is used during the initial stages of the investigation to generate a broad range of possible explanations for the fire's origin, cause, development, and spread. This approach encourages the FI to consider all reasonable possibilities without prematurely favouring a particular hypothesis. The objective is to ensure that potentially relevant causes, ignition sources, fire scenarios, and contributing factors are not overlooked.

Following the generation of potential explanations, **convergent thinking** should be applied to evaluate, organise, and prioritise the hypotheses based on the available evidence. Through a systematic assessment of facts, observations, witness information, analytical findings, and scientific principles, hypotheses that are unsupported, redundant, inconsistent with the evidence, or scientifically implausible can be eliminated.

The iterative application of divergent and convergent thinking assists the FI in:

- considering the full range of reasonable explanations
- avoiding premature conclusions and confirmation bias
- identifying alternative hypotheses that warrant further examination
- focusing investigative efforts on the most plausible scenarios
- systematically eliminating unsupported hypotheses
- developing conclusions that are supported by the available evidence and scientific principles

As additional information becomes available, the FI may need to revisit both processes, generating new hypotheses where appropriate and reassessing existing hypotheses in light of newly identified evidence. This iterative approach supports a robust, transparent, and scientifically defensible investigation.

12.1.3 Testing the hypothesis (or hypotheses)

The purpose of hypothesis testing is to develop, refine, and evaluate hypotheses relating to the fire origin, fire development, and potential cause(s) of ignition. Hypothesis testing is an iterative process in which the Fire Investigator (FI) applies scientific knowledge, professional competence, and investigative expertise to critically assess each hypothesis against the available evidence and all known facts established during the investigation.

The FI shall test each hypothesis by comparing it with observed fire effects, physical evidence, witness information, analytical findings, and scientific principles. As new information becomes available, hypotheses should be reviewed, refined, rejected, or further developed as appropriate.

Hypotheses may also be tested through:

- practical experimentation
- scene reconstruction activities
- analytical assessment using recognised scientific principles
- computer modelling and simulation, where validated and appropriate
- review of relevant scientific literature and published research

Where practical testing is undertaken, experiments may be conducted in situ, where conditions permit, or within appropriately equipped laboratories or certified test facilities. Any experiments should be designed, documented, and performed in a manner that ensures scientific validity and reproducibility.

Where scientific research is relied upon to support or test a hypothesis, the relevant literature shall be referenced and cited within the investigation records and, where appropriate, within the final report.

The hypothesis-testing process shall continue until all reasonable hypotheses have been examined and evaluated. Conclusions should be based on the hypothesis that is most consistent with the available evidence and established scientific principles. Hypotheses that are inconsistent with the evidence should be eliminated and the rationale for their exclusion documented.

12.1.3.1 Evaluation of Causal Factors

Any hypothesis relating to causal factors, including the first fuel ignited, ignition source, ignition sequence, or fire spread, shall be based on demonstrable facts. These facts may be derived from:

- physical evidence
- scene observations

- reliable witness information
- analytical results
- measurements and calculations
- experimental findings
- established scientific principles

Speculation, assumption, or unsupported opinion shall not form part of the analytical process. Considerations that may assist in testing hypotheses include whether:

- there was a single area of origin or multiple areas of origin
- the fire originated at location A, location B, or both
- the proposed ignition source, electrical fault or failure mechanism was capable of igniting the hypothesised first fuel
- there is evidence that an ignition source was present before the fire
- the proposed ignition mechanism is scientifically and technically feasible
- the estimated time required for ignition is consistent with the known timeline of events
- the proposed circumstances that brought the ignition source into contact with the first fuel ignited are consistent with the observed physical evidence
- any identified electrical fault existed prior to the fire or was caused by exposure to fire-related heat and damage
- the observed fire patterns are consistent with the proposed hypothesis of origin and cause
- the observed fire damage is consistent with that would be present if the hypothesis was correct
- the observed damage is consistent with the expected fire dynamics and fuel characteristics

12.1.3.2 General Considerations During Hypothesis Testing

Throughout the investigation, the FI should continually assess the extent to which the evidence supports or contradicts each hypothesis. Considerations may include:

- the probability or likelihood of the observed fire damage patterns under each proposed origin and cause scenario
- whether the observed fire effects are consistent with the proposed area or point of origin
- materials, residues, components, or artefacts remaining within the area of origin
- whether samples are needed for laboratory examination or analysis
- ventilation effects on the fire's development
- the relationships between fire dynamics, compartment conditions and the observed fire patterns
- effects from firefighting activities, structural collapse, fire suppression media used, or post-fire disturbance on the available evidence

12.1.3.3 Additional Considerations in Suspected Deliberate Fires

When investigating a suspected deliberate fire, the FI should consider whether the fire scene contains evidence of human activity associated with the ignition, development, or concealment of the fire.

Evidence of deliberate fire-setting may include fire patterns, scene modifications, ignition devices, fuel packages, or indications of multiple ignition locations. However, investigators should recognise that many such indicators may be altered or destroyed by fire development, particularly following flashover.

Following scene examination and reconstruction, the FI should consider whether:

- witness accounts correspond with the observed fire patterns and physical evidence
- there is evidence to support the location of the fire's origin as indicated by witnesses
- the fire could have spread to the reported location from an alternative origin and, if so, at what stage of fire development this could have occurred
- different fire patterns could reasonably be expected if witness information is accurate
- the observed fire patterns are consistent with the reported discovery and progression of the incident
- the overall fire damage is consistent with the range of considered hypotheses for origin and cause
- any of the hypotheses be excluded based on the available evidence

12.1.3.4 Documentation of Findings

The FI shall ensure that all potential ignition sources within the identified area of origin are examined and that all reasonable hypotheses are considered and tested. Where appropriate, hypotheses should be narrowed through a systematic process of elimination.

The rationale for accepting, refining, or rejecting a hypothesis shall be clearly documented within the case record. The investigative conclusion should be transparent, scientifically defensible, and supported by the totality of the available evidence.

12.1.4 Final hypothesis

Where possible, the FI should arrive at a final hypothesis relating to the origin of and potential cause(s) for the fire from iterations of refinement of earlier hypotheses. If the final hypothesis is at odds with information given by a witness, then this must be fully documented.

12.1.5 Bayesian Approach

The Bayesian approach may be used in the evaluation of evidence. This consists of estimating the probability of obtaining the findings under two alternative propositions. Where possible, the estimated probabilities should be based on published statistical and/or ground truth data. Using this approach, the FI must state the conclusion in relation to these probabilities, which are often expressed as a likelihood ratio and typically in a predefined verbal statement. See ENFSI's Guideline for Evaluative Reporting in Forensic Science [m1_guideline.pdf](#) for further information.

Where published statistical or ground truth data is unavailable, a personal, professional opinion on the statement of a probability of a fire cause based on the FI's experience and expertise may be acceptable, dependent on local jurisdictions. However, this is predicated on two conditions: (i) a thorough evaluation of all the evidence and information is conducted, and (ii) all assumptions and information that are included or excluded in the decision-making process are transparently and explicitly stated. Otherwise, the opinion on a stated probability may be misleading if it is not transparent or if the related case information is limited.

Note: The scientific method (hypothesis testing) and Bayesian approach (evaluating a pair of propositions) are not mutually exclusive. Indeed, the two are related - the goal of hypothesis testing is to infer whether a corresponding proposition is valid.

12.2 Conclusion

The conclusion should:

- aim to address the investigation's original purpose or problem
- provide a succinct summary of the results of the investigation
- include a clear, unambiguous expression of a final opinion
- where appropriate, use the verbal scale described by ENFSI's Guideline for Evaluative Reporting in Forensic Science
- wherever possible, include an expression of the uncertainty of measurement in relation to the determination of origin and cause, any assumptions used as part of the interpretation, and any limitation of the investigation

13. PRESENTATION OF RESULTS

The way in which a report is written can vary from country to country. The list (Table 4) below is recommended as a checklist of what a report should contain. The senior management and quality management departments for each institute are responsible for ensuring that procedures for the reporting and peer review of results are implemented.

Table 4. Example of 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 FI/specialist responsible
Working methods	Investigation by scientific methods Excavation and reconstruction Hypothesis testing or proposition evaluation
Background information	Information relevant to assessing the fire scene: • from people • from technical systems
Fire investigation (technical)	Limitations Descriptions of objects Descriptions of investigation results: • outside and inside together with windows and other openings • injured people and/or fatalities • list of contexts/ • list of evidential materials recovered from the scene and their chain of custody • the results of any tests carried out in situ • the results of any laboratory tests and analyses carried out on recovered samples or exhibits
Assessment and conclusion	Where relevant, reference should be made to key sources of uncertainty. Conclusions from hypothesis testing or proposition evaluation regarding: • the area or point of origin • the cause of the fire
Definitions and references (as appropriate)	Definitions of the most common and important scientific or technical terms References to validated literature Building plans and drawings

14. HEALTH AND SAFETY

The health and safety of workers is protected across the European Union by a series of standards derived from Directive 89/391/EEC. In addition to this Directive, a number of EU and non-EU aligned states have introduced their own Health and Safety at Work legislation. The legislation generally gives the employee the right to work in an environment as safe as reasonably practicable but also imposes the duty to work safely.

One of the core principles of all this legislation is that these rights and duties extend to crime and fire scenes. Good practice would be to identify one officer on site who takes on general responsibility for ensuring that good Health and Safety practices are followed.

A fundamental principle of Health and Safety in the workplace is that where a hazard is identified and that hazard creates a risk of harm, there is a hierarchy of actions:

- a) Remove the hazard – if that cannot be reasonably achieved, then
- b) Control the risk of harm – if it is not practical to control the risk, then
- c) Mitigate against the risk of harm.

Everyone involved in the investigation and examination of a fire scene has an important role in ensuring that hazards are identified, assessed, and managed appropriately. Fire scenes can present a wide range of risks to personnel, and a thorough risk assessment should be undertaken before and during scene examination. Potential hazards that may be encountered at a fire scene (ECHA, 2024; DeHaan and Bonarius, 1988) include, but are not limited to:

- structural collapse
- falling debris, objects, or masonry
- fall from height during access or examination activities
- exposure to noxious gases, smoke, or oxygen-depleted atmospheres, particularly in confined spaces
- electrical hazards from damaged or energised installations
- chemical and biological hazards (Brandes and Möller, 2008)
- airborne particulates
- sharps, such as broken glass, metal fragments, and needles
- uneven, unstable, or fragile floor surfaces
- low oxygen environment
- explosive environments
- inadequate or poor lighting conditions
- adverse weather conditions

Effective hazard recognition and the implementation of appropriate control measures are essential to minimise the risk of injury or ill health to investigators and other personnel operating at the scene. Where appropriate, investigators should seek advice and guidance from their organisation's Health and Safety personnel to ensure that appropriate risk assessments and control measures are implemented before undertaking scene examination activities.

14.1 Safety and Working Conditions

Following the hierarchy of H&S activity, the first duty is to remove the hazard where possible and practical.

An investigation may have to be delayed until it is deemed safe to enter the structure. Remedial 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. Utilities such as electricity or gas must be isolated by fire service personnel or appropriate engineers before investigation may begin.

In each case, the activities carried out to make the location safe should be recorded and the FI should obtain copies of any risk assessments or certificates.

Where a hazard cannot be removed, an attempt should be made to control the risk it presents. So, for example, where roofing material could not be moved due to the potential to cause damage to another part of the scene or a deceased, a control officer could be used to monitor the roofing material while work is carried out and to alert the

FI to a potential fall of the material. Other controls in this instance may include avoiding work in windy conditions, etc. Alternatively, where the presence of harmful particulates, such as asbestos, is suspected, it may be agreed that excavation will be minimised and/or that the debris will be dampen prior to work being carried out.

Again, any measures put in place to control the risk of harm should be recorded within a risk assessment.

The final option would always be to provide personal protective equipment (PPE) and respiratory protective equipment (RPE). Use of PPE/RPE is required when it is impractical to remove or control all risks. These may include hazards such as airborne particulates, for which an FFP3 respirator might be appropriate, or hazards associated with sharp or uneven flooring, for which safety boots with reinforced toes and midsoles may be worn.

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

The FI must undertake their own risk assessment at the scene and be aware that they are responsible for their own safety as well as those around them. This risk assessment must be dynamic and updated to reflect any remedial activities within the scene, any control measures, and any PPE/RPE worn. Be aware that some risks, e.g. decreased integrity of the building construction, can occur long after the fire is extinguished.

The outside area must also 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), and other hazards. If necessary, specialist advice must be sought.

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

This information must be communicated to all personnel on site and to any specialist upon their arrival.

14.2 PPE and RPE

It is advised that the FI prepare their checklist of personal protective equipment (PPE) and respiratory protective equipment (RPE). This list should be retained alongside inventories of other equipment so that the FI has options available for any reasonably foreseeable set of circumstances.

This list should include (but is not limited to):

a) PPE (see also [Appendix C](#) "Protective Clothing"):

- coveralls
- nitrile gloves
- slash and puncture resistant gloves
- chemical resistant gloves
- eye protection (glasses or goggles)
- hard hat
- safety boots (with reinforced toecaps and midsole)
- high visibility outer wear
- knee pads

b) RPE (see also [Appendix C](#) “Protective Clothing”):

- minimum of FFP3 half face respirator

RPE must be fitted and worn in accordance with the manufacturers’ instructions and recommendations. Wearing a fitted face mask is only effective when the wearer is clean-shaven.

c) Sterile Outerwear:

- Tyvek paper suit (or similar)
- nitrile gloves (long and short cuff – ideally in two colours)
- overboots / overshoes (to be worn where appropriate)
- surgical mask
- hair net / beard snood

Where forensic-grade PPE is required, it should be donned in a prescribed sequence to minimise the risk of contamination during the dressing process. The order in which PPE is worn should be clearly defined and followed consistently to maintain the integrity of the scene and any evidence present.

PPE should be put on in the following order:

- respirator
- hairnet (if worn)
- gloves (inner pair)
- paper suit
- overboots / overshoes (if worn – may be left until just outside the scene)
- gloves (outer pair)

Any PPE/RPE used should be appropriate for the task and conform to the national quality standards where the FI is working. Items of PPE/RPE should be ‘in date’ and should not be worn if they are past their ‘use by’ date or are damaged in any way.

In addition, the FI may wish to bring electronic safety devices or personal alarms to control any risks associated with hazards at a fire scene. These may include oxygen detectors (to measure oxygen levels) or chemical detectors (to alert the investigator to the presence of toxic industrial chemicals). Where the investigator wishes to bring these into a scene, they must follow the manufacturers’ instructions carefully and be competent to operate that equipment.

14.3 Further Information

For further information, please see the European Commission document: “Health and Safety at Work Is Everybody’s Business – Practical Guidance for Employers” (European Commission, 2016).

Alternatively, practical advice and guidance can be found on official European or national health and safety website, e.g. European Agency for Safety & Health at Work - Information, statistics, legislation and risk assessment tools, or www.hse.gov.uk.

In addition, a training module is available at CFITrainer.net that covers Donning and Doffing Personal Protective Equipment.

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16. AMENDMENTS TO PREVIOUS VERSION

Various sections and appendices of BPM version.4, including aspects of its structure, have been revised and updated. The changes have been made with the general purpose of aligning the BPM with contemporary standards, so that it remains relevant and continues to be applicable and useful for all our state institutes. Where deemed suitable, attempts were made to infuse quality management language into the guidance and recommendations to further align the document with internationally recognised guides and standards, such as NFPA 921, ILAC-G19, ISO/IEC 17020, ISO/IEC 17025 and ISO 21043.

Some common themes for revision were identified and these broadly related to (see Figure 10):

- the scope of the document
- roles and responsibilities
- information relevance, consistency, consolidation and presentation
- general applicability/usability
- currency of sources of information

Suggested topics for inclusion from the Working Group at recent annual meetings were considered and, where feasible, added to the new version of the BPM.

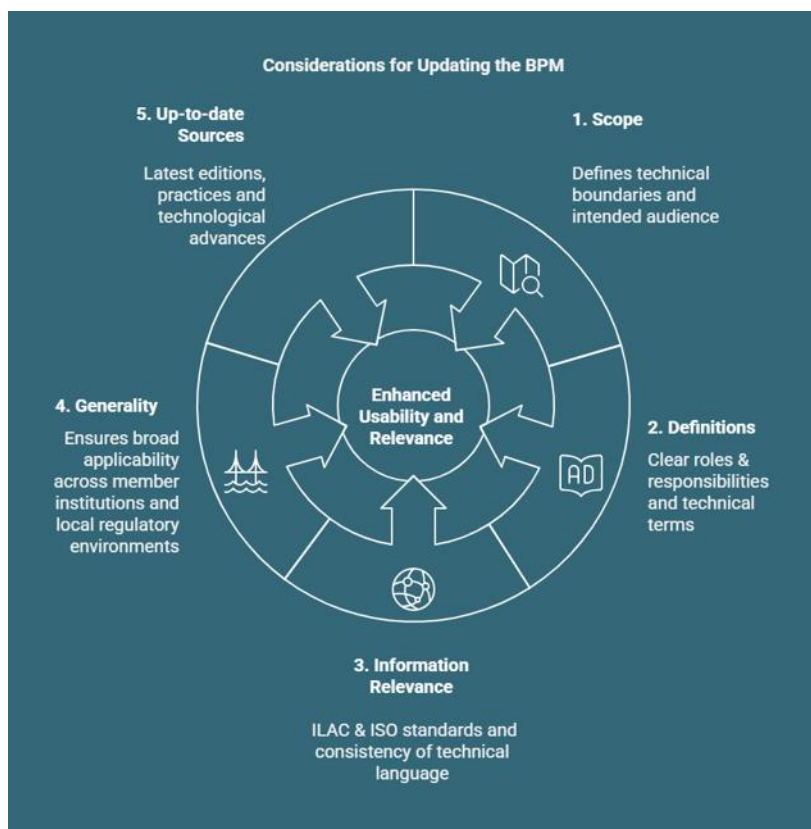


Figure 10. Principles and considerations for amendments to the BPM

While it would be impossible to list every amendment that has been made to version 4, the following is a broad overview of the main changes, in no order of priority:

- The appendices are numbered differently. They are now in alphabetical order.
- The previous appendices A1 and A2 have been consolidated into Section 5, “Methods”.

- c) Several new appendices on specialist topics have been added, e.g. guidance on investigating EV and Li-ion battery fires, wildfires, clandestine drug lab fires, fatal fires, forensic case strategy, DNA recovery from blood contaminated with soot, digital investigations, health and safety, and education and training.
- d) Technical definitions for fires and explosions, previously listed separately in their respective appendices, have now been consolidated into a single appendix – [Appendix N](#) “Glossary of Terms”.
- e) The lists of references for the investigation of fires and explosions, previously listed separately in their respective appendices, have now been consolidated into a single section – [Section 15 “Bibliography”](#).
- f) The listed sources of information have been updated.
- g) Some sections have been updated and/or expanded to include examples of contemporary practices, e.g., the use of LiDAR 3D scanning (Tredinnick, R., Smith, S. and Ponto, K., 2019) and photogrammetry, and to provide further guidance on specific topics, e.g., validation and measurement of uncertainty; handling of test items (samples).
- h) The language within the BPM has been updated to better align with ISO standards and general quality assurance principles.

APPENDIX A – TASKS FOR FIRST RESPONDERS

The responsibilities of first responders upon arrival at a fire or explosion scene may include, but are not limited to, the following:

- **secure the scene** by restricting unauthorised access and establishing appropriate cordons
- **preserve the scene** by preventing unnecessary disturbance of potential evidence and ensuring that items are not moved, altered, or removed unless required for life-saving purposes
- **assess the scene for casualties** and identify any injured or vulnerable persons
- **notify supervisors and emergency communications centres** to request additional resources and specialist support, where required
- **provide or facilitate first aid** to injured persons, where it is safe and appropriate to do so
- **protect vulnerable evidence** that may be liable to loss, contamination, damage, or deterioration (e.g. a discarded fuel container) by maintaining adequate scene security and controlling public access
- **identify and communicate immediate hazards** to personnel attending the scene
- **record relevant observations**, including:
 - the location of the fire and the materials or objects involved upon arrival
 - the security status of the premises on arrival, including whether doors or windows were locked, unlocked, open, damaged, or forced.
 - whether any fire alarm or other warning system was operating
 - whether any persons were present within or around the premises, and, if so, their identities and activities
 - the exact location of casualties and injured persons
 - the nature and apparent severity of injuries sustained (Centers for Disease Control and Prevention, 2023)
 - the location and condition of any obvious evidential material
 - details of any hazards identified at the scene
- **obtain initial witness accounts**, where appropriate, including:
 - who first discovered the fire
 - how the fire was detected or reported
 - the location of the fire when it was first observed
 - what materials, contents, or structures were involved when the fire was first discovered
 - the security status of the premises when the fire was first detected, including the condition of doors and windows
 - whether any individuals were observed leaving the scene before or after the fire was discovered
 - whether any unusual, suspicious, or noteworthy activity was observed before, during, or immediately after the incident
- **maintain scene security and await the arrival of additional emergency service personnel**, ensuring that all observations, actions taken, and witness information are accurately documented and communicated
- **assist the investigating team** when requested and within the scope of their role and competence

These actions assist in safeguarding life, preserving evidence, maintaining scene integrity, and supporting subsequent fire and explosion investigations.

APPENDIX B – INVESTIGATION STRATEGY WITH CASE STUDIES EXAMPLES

1. FORENSIC STRATEGY PROCESS

By their nature, fire investigations are often part of a complex investigation with complex scenes that involve multidisciplinary working. In this environment, coordination of the forensic response to ensure that all practitioners and disciplines involved work together optimally is vital. An effective way to put this coordinated approach in place is to have a comprehensive Forensic Strategy (see Figure 11 for an outline of the forensic strategy process).

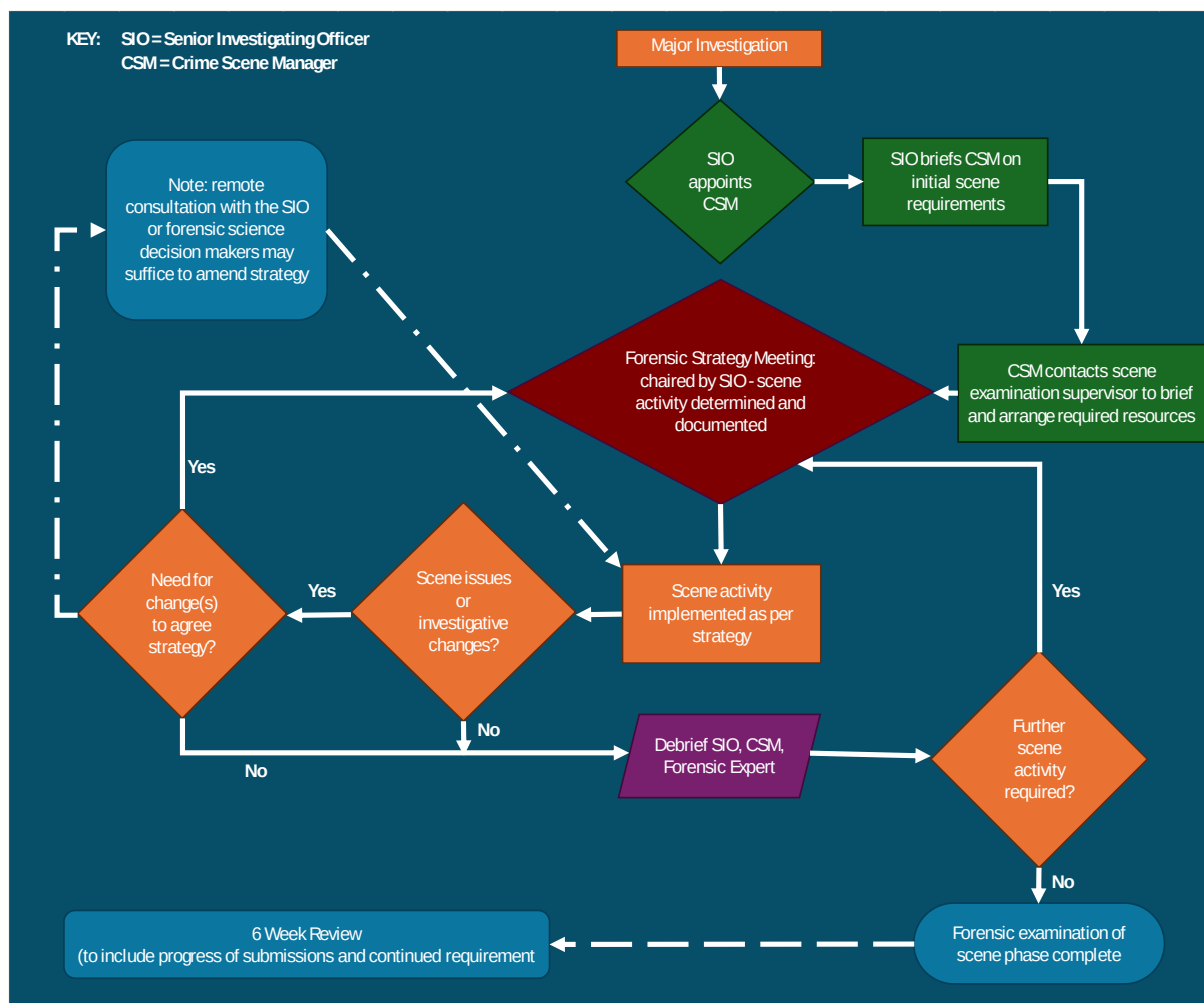


Figure 11. Forensic Strategy Process

The purpose of a forensic strategy is to ensure all forensic opportunities are considered and that their potentials are maximised. A forensic strategy comprises the individual examination strategies developed by forensic specialists to carry out their part of the overall forensic response. Consequently, a forensic strategy helps to ensure that a full, sequential examination of the scene and/or any recovered items is conducted. In addition, to the sequential examination strategies, a comprehensive forensic strategy will include:

- preservation and counter-contamination strategies – use of correct PPE/RPE, retention or disposal of used PPE, use of resources to minimise contamination.
- forensic protocols for dealing with witnesses or arrested people
- forensic protocols for dealing with postmortem examinations / sampling from victims.
- strategy for retention and prioritisation of samples or recovered items.
- process for reporting results back to the investigating or prosecuting authority or customer

2. FORENSIC STRATEGY MEETING

The forum for sharing a joint understanding of the circumstances and agreeing a forensic strategy is the Forensic Strategy Meeting. This usually takes place at the outset of a major or serious investigation. Major or serious investigations may include (but are not limited to) cases that are:

- complex, e.g. multiple scenes / victims etc.; multiple disciplines or agencies involved; large numbers of potential submissions for analysis
- historical, e.g. cold cases
- of special interest, e.g. deaths following Police contact
- problematic or challenging and there is value in having a forum to share and discuss priorities and actions

Prior to any Forensic Strategy Meeting, the Senior Investigating Officer or Investigating Authority should have a clear idea of their priorities for the examination. There may be more than one priority, but they should be simple (e.g. recovery of a body, establishing cause of death, establishing cause and origin of a fire) so that forensic practitioners can create a bespoke response to meet that priority.

The forensic strategy meeting should provide a detailed understanding of the circumstances and the investigation to date, address all the strategies listed above, and agree a sequential examination. A suggested sequential examination process for a fire scene is given below:

- i. Ensure safety and security of the scene and attending staff.
- ii. Recording of scene – photography, videography, 3D visualisation (e.g. 360° imaging, VR, LiDAR imaging and Gaussian splatting), sketch / plot, use of aerial drone, thermal imaging (handheld or drone mounted).
- iii. Recovery of deceased (if applicable) and subsequent postmortem activity. This may include attendance of anthropologist or pathologist.
- iv. Any DNA sampling or other biology-related work (e.g. blood pattern analysis) which impinges on the area of the deceased or potential area or point of origin (may include attendance of Forensic Biologist).
- v. Fire Investigation (including excavation and sampling).
- vi. Introduction of hydrocarbon detection dogs (if required).
- vii. Further sampling / recovery of items of evidential value.
- viii. General forensics work, e.g. other DNA work, fingerprint examination and recovery, footwear mark recovery.
- ix. Non-forensic search.
- x. Recovered items and samples to be assessed by the Reporting Scientist and prioritised for examination.
- xi. Items examined / samples analysed within a laboratory setting meeting ISO/IEC 17025 or ISO 21043 requirements, or similar.
- xii. Report to Investigating Authority.

3. STRATEGY FOR IMAGING THE SCENE

Strategy for imaging the scene will include conventional photography which provides comprehensive views of the external scene and internal scene. Aerial drones may be used externally but not recommended internally. This imaging should create an accurate representation of all rooms, fire patterns and other items of investigative value prior to any items being recovered. Other imaging techniques may include specialist methods for capturing the fire scene to facilitate accurate 3D virtual reality recreation (Yu *et al.*, 2023) using photogrammetry or Gaussian splatting. LiDAR or 360° imaging, hyperspectral imaging cameras, RGB-D cameras, and IR and UV cameras may also be used. It should be noted that any imaging technique must have scientific validity and be generally accepted as capable of

producing accurate and reliable representations of the scene. Images should be captured in RAW format.

4. WHO SHOULD BE PRESENT AT A FORENSIC STRATEGY MEETING?

The following are people who should be present and have an input:

- senior investigator
- FIs
- Fire and Rescue Service (if not FIs)
- Pathologist (if required)
- specialist for body recovery (anthropologist – if required)
- other forensic disciplines (depending on requirements of scene)
- Crime Scene Manager (or equivalent)
- photographer / scene examiner / CSI
- utility company representative (if main supply for utility concerned is not already isolated)

Note – this is not an exhaustive list. Attendees should be appropriate to the case.

5. EXAMPLES OF CASES WHERE FORENSIC STRATEGY MAY BE AMENDED

Example 1: Making the scene safe when there were competing counter-contamination issues.

Damaged wooden structure identified during the Forensic Strategy Meeting. The circumstances, as they were understood, suggested the potential for the use of ignitable liquids within the scene, and this observation precluded the use of petrol-driven chainsaws or similar for cutting away the damaged structure. Battery-powered tools were identified as suitable for the task and so they were used to mitigate the risk of contamination of the scene.

Example 2: Requirements for early recording of the scene with competing priorities.

A large structure fire resulted in the partial collapse of the building. At the start of the enquiry, it was not ascertained whether there was a deceased within the scene. The Senior Investigating Officer set this as a priority and required confirmation of the presence/absence of a body. Cadaver / search dogs were unavailable. A small quad-copter type drone was used to provide views within the scene, and this confirmed the presence of the deceased. This then allowed the forensic response to react accordingly, and it was agreed that priority would be given to making that area of the building safe to work within in order to recover the body first. Fire investigation was considered a secondary priority.

Example 3: Requirement to secure deceased for postmortem examination with competing forensic issues.

Large structure fire had resulted in deceased being left exposed and on open display in an investigation where a domestic murder was suspected but the identity of the deceased could not be confirmed visually. The deceased was in an area that would take some time to reach by normal means. Priority for Investigating Authority was the recovery of the deceased ahead of the fire investigation. A common approach path was established through the scene to the

deceased with oversight from the FI. Path was created and the scene was searched by Police Searchers.

Example 4: Requirement to enter scene for examination purposes with competing forensic issues.

Small fire and death of elderly resident. There was history of neighbour disputes. Only one potential point of entry which was insecure. No other option for entry and exit. DNA and fingermark recovery were carried out to the door, door furniture and undamaged surfaces within the scene prior to entry. This ensured that activities did not compromise the integrity of forensic evidence during body recovery and the subsequent fire investigation.

Example 5: Various competing issues within a vehicle subject to a witnessed self-immolation.

Deceased remained in situ within the vehicle while firearm and ammunition were suspected of being present within the fire damaged vehicle. There were issues around the identification of the deceased. Recovery of accelerant and container was also a priority. Decision was made to use a secure container to move the vehicle to a sterile lab space away from public view. There was limited potential damage to forensic evidence from Fire and Rescue Service, so a decision was made to have the roof of the vehicle removed within the lab space to grant easier access. Thereafter, to have staff from Chemistry, Biology, Scene Examination and Firearms teams present simultaneously to work together.

Example 6: Requirement for extra scene preservation measures during investigation of a linked series of fires.

Process was put in place with the Fire and Rescue Service to have scenes and vehicles nominally linked to the suspected series of fires marked as 'code red'. This would prompt the Fire and Rescue Service first responders to adopt a soft approach to extinguishing the fire. First responders in attendance would also take greater care around movement and handling of items. All the implemented steps were intended to preserve evidence within the scene(s).

Example 7: Requirement for streamlining of reporting process during investigation of a large number of linked fires and other crimes.

Senior member of Forensic Services staff was given the responsibility for overseeing the forensic response. Single points of contact were identified across the disciplines involved. Timelines were agreed for analysis and reporting. Methods of reporting were agreed to allow for the prosecuting authority to have sight of forensic or inceptive intelligence without the need for continual formalised reporting.

APPENDIX C - PROTECTIVE CLOTHING

Personal safety equipment – basic (and minimum):

- safety helmet
- safety boots (with steel sole and toecap)
- face mask, e.g. FFP3
- protective goggles
- protective gloves and gauntlets (industrial gloves and chemical-resistant rubber gloves).
- work clothing, e.g. reusable overalls
- disposable overalls (dust-proof overalls)
- lighting equipment
- ear defenders
- mobile phone, in case if lone working

Follow the path in Figure 12 to find the fire scene that is representative to yours.

Where applicable, add to the basic protective clothing listed above the recommended additional protective equipment (far right-hand column).

See also [Section 14: “Health & Safety”](#).

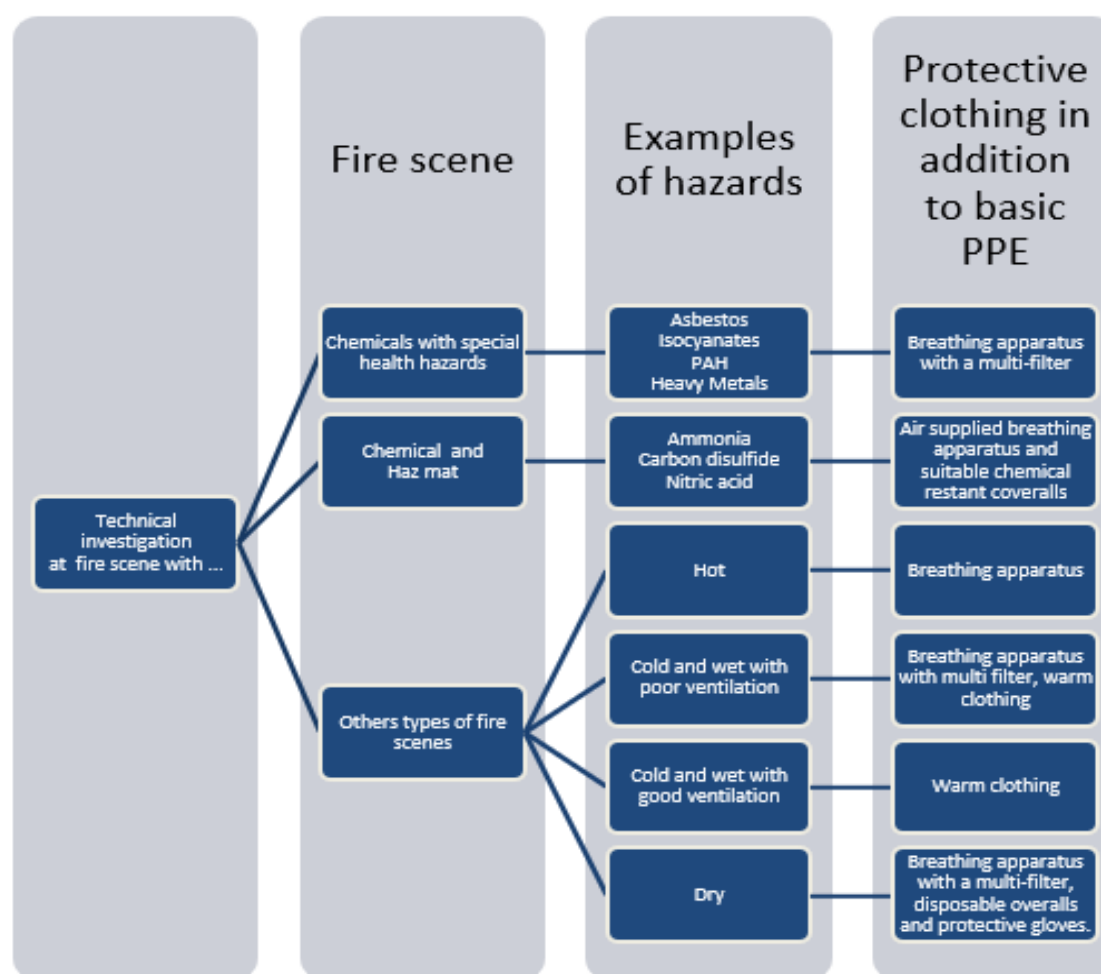


Figure 12. PPE and types of fire scenes

APPENDIX D – INVESTIGATION OF VEHICLE FIRES

In addition to the general guidance provided elsewhere in this BPM, this appendix sets out specific recommendations for the investigation of vehicle fires. Vehicle fires present unique investigative challenges due to the complexity of vehicle systems, the variety of fuel and propulsion technologies in use, and the potential for extensive fire damage to obscure the area of fire origin and cause.

1. INFORMATION GATHERING

The vehicle owner, driver, and other occupants may be able to provide valuable information regarding the circumstances of the fire. Where appropriate, investigators should seek to establish:

- whether the vehicle exhibited any signs of mechanical, electrical, or operational problems before the fire, such as loss of power, warning lights, overheating, unusual odours, smoke, or electrical malfunctions
- whether the vehicle was stationary or in motion when the fire was first detected
- the distance travelled and duration of operation immediately prior to the fire
- any activities undertaken by the occupants before the fire, including smoking, charging electronic devices, handling flammable materials, or carrying out repairs
- the vehicle's maintenance and service history, including details of any recent repairs, servicing, recalls, or replacement of components
- whether the vehicle had been modified from its original manufacturer's specification
- whether the vehicle was carrying any hazardous materials, pressurised containers, fuels, chemicals, or other combustible goods
- whether the vehicle is equipped with a data recording system, such as an Event Data Recorder (EDR), accident data recorder, telematics system, fleet management system, or other onboard data-logging devices that may provide information relevant to the investigation
- the circumstances in which the fire was discovered and the actions taken by occupants prior to evacuation or firefighting efforts.

2. FACTUAL INFORMATION TO NOTE:

The following information should be documented as part of the vehicle examination:

- vehicle make, model, and year of manufacture
- vehicle registration number
- Vehicle Identification Number (VIN) - the VIN may be found in several locations, including the engine compartment, door pillar, chassis, dashboard, and at the base of the windscreen
- vehicle colour and any distinctive markings or features
- vehicle type and body style (e.g., passenger car, van, truck, bus, motorcycle, agricultural vehicle, or construction plant)
- odometer reading, where available
- type of propulsion or fuel system, including:
 - petrol (gasoline)
 - diesel
 - liquefied petroleum gas (LPG)
 - compressed natural gas (CNG)
 - hybrid electric
 - battery electric vehicle (BEV)
 - hydrogen fuel-cell vehicle
 - other alternative fuel systems

- vehicle ownership details and operator information, where available.
- location of the vehicle when the fire occurred
- environmental conditions at the time of the incident, including weather, road conditions, and surrounding exposures
- any evidence of collision damage, vandalism, forced entry, or other pre-existing damage
- the position of doors, windows, bonnet, boot, fuel filler cap, and other access points upon arrival
- the condition of electrical, fuel, hydraulic, and cooling systems as observed during examination (see later sections in this appendix)

3. INITIAL OBSERVATIONS

Investigators should carefully record their initial observations before any intrusive examination is undertaken, including:

- the overall extent and distribution of fire damage
- areas of greatest damage and potential fire origin
- evidence of fuel leakage or fluid spills
- evidence of electrical arcing, short-circuiting, or component failure
- the condition of tyres and wheels
- the condition of the engine compartment, passenger compartment, luggage compartment, and underbody
- the presence of unusual fire patterns, localised burning, or indicators of multiple areas of origin
- the operation and condition of safety systems, including airbags, battery isolation systems, and fuel shut-off devices
- the presence and location of any potential evidential material

4. SAFETY CONSIDERATIONS

Vehicle fire scenes may present significant hazards. In addition to the general health and safety guidance contained elsewhere in this BPM, investigators should consider:

- residual heat and re-ignition risks
- damaged fuel systems and fuel leaks
- pressurised components and cylinders
- electrical hazards from damaged wiring and electrical systems
- high-voltage systems associated with hybrid and electric vehicles
- thermal runaway and delayed ignition risks from lithium-ion batteries
- airbag deployment systems and pyrotechnic devices
- sharp metal edges and damaged vehicle components
- hazardous combustion products and airborne particulates
- vehicle instability resulting from collision or fire damage

A dynamic risk assessment should be conducted before and throughout the examination, and appropriate specialist assistance should be sought where necessary.

5. VEHICLE EXAMINATION

Vehicle examinations should be conducted systematically and documented thoroughly using contemporaneous notes, photographs, sketches, and other appropriate recording methods. Attention should be given to preserving potential evidence associated with:

- mechanical failure

- electrical failure
- fuel system defects
- deliberate ignition or accelerant use
- vehicle modification or unauthorised alterations
- product defects or component failures
- collision-related causes
- malicious damage or criminal activity

All evidence should be handled, packaged, labelled, and stored in accordance with established evidential procedures to maintain continuity and integrity throughout the investigation process.

The FI must consider the vehicle's security in all instances. The vehicle's doors and windows should be examined, and, wherever possible, their status at the time of the fire (i.e. whether open or closed, intact or broken) should be determined.

The presence or absence of intruder alarms and sensors must be noted. Any apparent interference with the vehicle's alarm systems must be recorded.

If a fatality is involved and the body is still in situ inside the vehicle, then the FI must record its location, orientation and context in relation to the fire together with the condition of exposed surfaces and any surviving clothing. A visual inspection should be made for any obvious signs of non-accidental injury, the presence or absence of which should be noted. When the body is moved, the condition of the previously hidden surfaces and any materials trapped beneath the body and protected from the fire should be recorded (see [Section 8.1.5](#) and [Appendix F](#) "Fatalities" for additional information).

The FI should examine as much of the scene as possible and identify the area(s) of interest that will be subjected to a more detailed examination. The extent of the damage and the patterns of fire and smoke spread within the vehicle (and the surrounding scene) should be documented in sufficient detail so that a later review of the case notes will clearly show that the fire could only have started within the area(s) of interest.

Excavation and reconstruction in the area(s) of interest should be fully documented. Where it is considered relevant to the investigation, the stratigraphy of the materials removed should be clearly recorded together with an explanation of its significance.

Where objects of forensic significance, either as indicators of the area of origin of the fire or as potential ignition sources, are identified during excavation, an attempt should be made to return them to the positions they occupied during the fire.

Following excavation and reconstruction of the vehicle, and where circumstances permit, the Fire Investigator (FI) should determine, document, and record the following:

- the presence or absence of the vehicle's ignition key within the ignition switch or ignition barrel
- where a key is present, its exact position should be recorded, as this may assist in determining whether the vehicle's electrical system was switched on or off at the time of the fire
- investigators should note, however, that certain electrical systems and components may remain energised even when the ignition is in the off position
- if the ignition key is not present in the ignition barrel, the location in which it was subsequently found should be documented
- the position of the gear selector or gear lever, as this may provide an indication of whether the vehicle was stationary or in motion at the time of the incident
- the position and condition of the parking brake (handbrake)
- any evidence suggesting theft from the vehicle, including missing audio equipment, navigation systems, sporting equipment, personal property, or other valuables

- the presence or absence of potential human-related ignition sources, including matches, lighters, smoking materials, incense burners, candles, or similar items
- the presence or absence of any odour associated with ignitable liquids within the vehicle
- the presence or absence of ignitable-liquid containers or other vessels capable of containing flammable liquids
- the presence or absence of items of investigative significance, such as identification documents, vehicle ownership records, insurance documentation, electronic devices, or personal effects
- the presence or absence of extraneous or suspicious items, including weapons, incendiary devices, bricks, rocks, or other objects that may be relevant to the circumstances of the incident.
- the condition of the fuel filler cap, including whether it is secured, damaged, tampered with, or unlocked
- the fuel filler area should also be examined for the presence of foreign materials or objects within the filler neck or port, such as rags, paper, cloth, or other materials that may be indicative of deliberate ignition or fuel contamination

All observations should be accurately recorded and supported, where appropriate, by photographs, sketches, measurements, and contemporaneous notes to ensure evidential integrity and facilitate subsequent analysis.

5.1 Checking the Fuel System

Where appropriate, the FI may wish to examine the integrity and condition of the vehicle's fuel system, including those fitted with liquefied petroleum gas (LPG) or other alternative fuel systems. Such examinations may assist in identifying whether fuel leakage or fuel system failure contributed to the ignition, development, or spread of the fire. Consideration should be given to the following:

- fuel lines, hoses, pipes, tanks, fittings, valves, regulators, and associated connections should be examined for evidence of pre-fire defects, deterioration, leakage, corrosion, damage, or failure
- where abnormalities are identified, the FI should attempt to determine whether they occurred before the fire, as a consequence of the fire, or as the result of subsequent recovery operations, collision damage, or other external influences
- where a fuel leak is suspected and sampling is considered necessary, the FI should document the original position of the vehicle and note the gradient and direction of slope of the ground surface on which it was located (this information may assist in interpreting the movement, accumulation, or distribution of leaked fuel and associated fire patterns).
- the presence or absence of non-manufacturer or non-factory-installed modifications to the fuel system should be recorded.
- particular attention should be given to modifications involving fuel tanks, fuel lines, pumps, pressure regulators, filler assemblies, LPG installations, or other components that may have affected the safety or integrity of the system
- any evidence of fuel leakage, staining, residue, abnormal deposits, or damage associated with fuel system components should be documented and photographed before further examination or dismantling is undertaken
- the condition and security of fuel tanks, filler necks, fuel caps, vents, and associated components should be assessed for evidence of damage, tampering, impact, corrosion, or leakage

5.1.1 Hybrid and Electric Vehicles

For hybrid and battery-electric vehicles, particular attention should be given to the condition of the high-voltage battery system and its associated components. The FI should assess, where safe and practicable:

- the integrity of battery modules and individual cells
- evidence of pre-fire damage, impact damage, manufacturing defects, or degradation
- signs of thermal runaway, internal cell failure, venting, arcing, or overheating
- damage to high-voltage cabling, connectors, isolation devices, and battery management system components
- the operation and condition of any battery isolation or emergency shutdown systems

Specialist assistance should be sought where necessary, particularly when examining damaged high-voltage systems or batteries that may present a risk of re-ignition, electrical shock, or hazardous substance release.

Further guidance on the investigation of electric vehicles and lithium-ion battery incidents is provided in [Appendix D on “Electric vehicles and Li-ion batteries”](#).

5.2 Checking the Lubrication Systems

Where appropriate, the Fire Investigator (FI) may wish to examine the integrity and condition of the vehicle's lubrication systems. Failures within lubrication, hydraulic, braking, transmission, steering, or suspension systems may contribute to fire development through the release of combustible fluids onto hot surfaces or electrical components. Accordingly, consideration should be given to the following:

- lubricating oil, hydraulic fluid, transmission fluid, power steering fluid, brake fluid, and suspension system pipework, hoses, reservoirs, seals, gaskets, fittings, valves, and associated components should be examined for signs of pre-fire defects, deterioration, leakage, wear, corrosion, mechanical damage, or failure
- where such evidence is identified, the FI should seek to determine whether the condition existed prior to the fire or occurred as a consequence of the fire, collision damage, recovery operations, or other post-incident events
- the presence of fluid leakage, staining, deposits, contamination, or residues associated with lubrication or hydraulic systems should be documented and photographed prior to dismantling or intrusive examination
- where appropriate and practicable, fluid levels within relevant systems may be assessed and recorded
- significant fluid loss may indicate leakage, system failure, or fire-related damage and should be interpreted in conjunction with other investigative findings
- particular attention should be paid to areas where combustible fluids may have come into contact with hot surfaces, including exhaust manifolds, turbochargers, catalytic converters, diesel particulate filters, braking components, and other heat-producing equipment
- the presence or absence of non-manufacturer or non-factory-installed modifications, repairs, or temporary fixes affecting lubrication or hydraulic systems should be recorded
- components removed for detailed examination or laboratory analysis should be appropriately labelled, packaged, and documented to maintain evidential continuity

5.2.1 Diesel-Engine Vehicles

For diesel-engine vehicles, the turbocharger and associated lubrication system should be examined for evidence of mechanical failure or oil leakage. Attention should be paid to damaged bearings, seals, and housings, as failure of these

components may result in the release of lubricating oil that could contribute to fire ignition or fire spread.

5.3 Checking the Cooling System

Where appropriate, the FI should consider examining the integrity of the engine cooling system. In such cases:

- water pipes, associated connections, valves, pumps, cooling fans and fins, ductwork, motors, and fan belts should be examined for evidence of pre-fire defects, deterioration, or damage
- where such conditions are identified, the FI should endeavour to determine whether they arose accidentally or resulted from another cause

5.4 Checking the Electrical and Electronic Systems

Where appropriate, the FI should consider examining the integrity of the vehicle's electrical and electronic systems.

When considering the possibility of an electrical source of ignition, it may be necessary for the FI to conduct a preliminary examination of any questioned electrical or electronic item(s) or component(s) at the scene. Where this is considered appropriate, the following information should be recorded where possible:

- the location of the vehicle battery, questioned component(s) and associated electrical relays in relation to the origin of the fire
- the condition of the vehicle battery, including whether it remained connected to the vehicle's electrical system at the time of the fire
- whether the questioned component was energised at the time of the fire
- the condition and integrity of relevant fuse(s) within the fuse panel, determined through visual inspection and, where appropriate, testing with a multimeter
- information obtained from the manufacturer to identify which electrical and electronic systems could have remained energised with the engine switched off
- the presence or absence of evidence of electrical activity, such as short-circuiting, resistive heating, arcing, or overload conditions
- the presence or absence of non-original or aftermarket electrical modifications

Following this preliminary examination, any questioned component(s) should be returned, as far as practicable, to the condition in which they were found. Wherever possible, the questioned component(s) should be recovered before the conclusion of the investigation and submitted to a suitably accredited laboratory for detailed examination.

Where appropriate, the FI should also consider examining a comparable, undamaged vehicle, such as one obtained through a dealership or manufacturer, for comparison purposes.

6. LOCATION OF THE AREA(S) OF ORIGIN

The FI must seek to assess the extent and distribution of fire damage and identify the area(s) of origin using the fire patterns and damage indicators revealed through excavation and reconstruction. Consideration should be given to:

- areas exhibiting the least and greatest fire damage, taking into account any variation in the degree of damage between the engine compartment, passenger compartment, and luggage compartment, as well as between the contents within them
- the apparent direction of fire spread

- effects of fire on external vehicle components, including bodywork, paintwork, tyres, wheels, and glazing, with comparisons made between similar components where appropriate
- effects of fire on the vehicle's contents, including upholstery, seat padding, and other interior materials, with comparisons made between similar components where appropriate
- the lowest level of burning
- the possibility of multiple areas of origin
- the presence or absence of ignitable liquid odours
- the condition and position of doors, windows, and other openings
- the ventilation conditions that existed at the time of the fire
- the presence of potential ignition source(s) within, or in proximity to, of the suspected area of origin

The FI should record the identified area(s) of origin together with an assessment of the level of certainty associated with those findings.

7. IDENTIFY POTENTIAL IGNITION SOURCES

The FI should endeavour to determine the cause of the fire by identifying the most likely ignition source, based on the evidence recovered and all relevant information available.

Potential ignition sources in vehicle fires might include:

- naked flames, such as lit matches or cigarette lighters
- incendiary devices
- embers, sparks, or other hot particles generated by hot-work activities (e.g. welding, cutting, or grinding operations), particularly where the vehicle was undergoing repair or maintenance
- lit smoking materials, such as cigarettes
- electrical and electronic components, including resistive heating resulting from poor electrical connections, overheating caused by excessive current flow, electrical arcing associated with short circuits, and overloaded circuits
- hot surfaces, including exhaust system components such as exhaust manifolds, turbochargers, catalytic converters, and associated pipework
- frictional heating arising from the failure or seizure of mechanical components, such as air-conditioning compressors, bearings, or other rotating equipment

This list is not exhaustive. The FI should consider any other actual or potential ignition sources identified through the investigation and evaluate their relevance to the circumstances of the fire.

8. ADDITIONAL INFORMATION

The FI should also consider and record, where relevant, the following information:

- whether there is any evidence or indication of poor vehicle maintenance, deferred repairs, or the use of unsuitable replacement parts
- whether the vehicle was involved in a road traffic collision or other impact event at, or immediately prior to, the time of the fire
- whether any vehicle recalls, technical service bulletins, or known manufacturer defects could be relevant to the fire.
- the FI should review appropriate sources of information to determine whether known defects or design issues may have contributed to the fire, including government and regulatory databases, such as:
 - the European Commission Safety Gate system

- the EU Vehicle Safety Branch Recalls Database (data.europa.eu),
- the Driver and Vehicle Standards Agency (DVSA)
- the Vehicle and Operator Services Agency (VOSA)
- the National Highway Traffic Safety Administration (NHTSA)
- vehicle manufacturer websites,
- if the vehicle was moved from the original fire scene before the FI's attendance, whether any vehicle components, cargo, or other items were removed, displaced, or found to be missing
- whether the vehicle had been reported stolen, unlawfully taken, or was otherwise associated with suspicious circumstances
- the condition and nature of the road surface or terrain where the fire occurred (e.g. paved road, gravel surface, unmade track, or off-road environment)
- whether the vehicle had been operating in the vicinity of overhead electrical conductors or other electrical infrastructure before the fire.
- consideration should be given to heavy goods vehicles (HGVs), plant, agricultural machinery, and vehicles carrying elevated loads, where accidental contact with overhead power lines may have occurred
- any recent repair, maintenance, modification, or accessory installation work that may be relevant to the fire
- the vehicle's recent operating history, including any reported mechanical, electrical, or performance issues prior to the incident
- any witness accounts, driver statements, onboard telematics data, CCTV recordings, or other information that may assist in establishing the circumstances leading to the fire

The significance of any such information should be evaluated in the context of all other findings and evidence obtained during the investigation.

9. TAKING OF SAMPLES

The FI should consider the value of obtaining samples from the suspected area(s) of origin, or from any other relevant location, in order to preserve potential evidence and facilitate laboratory examinations that may assist in testing hypotheses developed during the investigation.

Where a sample is collected, the FI should, where practicable, obtain an appropriate reference sample from an unaffected or comparable area. Consideration should also be given to retaining a control sample of the packaging material used, which may serve as an environmental contamination control and assist in the interpretation of laboratory findings.

Samples should be collected by the FI, or by suitably authorised personnel acting under the FI's direction or supervision. The collection, handling, packaging, labelling, storage, and transportation of all samples should be undertaken in accordance with applicable international, national, and organisational procedures and standard.

Appropriate continuity and chain-of-custody records should be maintained for all samples and exhibits recovered during the investigation.

Any item seized or recovered for further examination must have its location, condition, description, and unique identifier accurately recorded within the case notes and any relevant exhibit documentation.

10. ELECTRIC VEHICLES AND LI-ION BATTERIES

Investigation of fires within Electric Vehicles (EVs) and Hybrid Electric Vehicles (HEVs) come with a series of associated risks in addition to the normal hazards that the investigator might

normally expect within a fire damaged vehicle. This section will address the identification and mitigation of those hazards before proceeding to the determination of origin and cause.

10.1 Identifying an EV/HEV

While it is expected that an investigator may already be aware of the fuel type, they must be able to identify a vehicle as an EV/HEV. Typically, there are several ways to do this:

- the licence plates of EVs and HEVs are likely to have a characteristic green stripe (Figure 13)



Figure 13. Vehicle licence plate with a characteristic green stripe

- EVs will not have an exhaust pipe but HEVs will.
- both EVs and HEVs are likely to have electrical charging ports except for self-charging HEVs
- depending on the location of the vehicle, the charging cable may still be in place or in close proximity
- remaining trim may indicate that the vehicle is an EV or HEV (see Figure 14)



Figure 14. Exterior trim detail of a plug-in HEV

10.2 Additional Risks and Mitigations

In addition to the 'generic' risks associated with any vehicle fire, such as sharps injuries, chemical burns or injury by undeployed / damaged pyrotechnics, EV/ HEVs come with a range of extra risks due to the presence of a large internal lithium-ion battery array. Such risks include:

- a) Electrocution – There is potential for exposed high-voltage wiring to come into contact with the vehicle's chassis or body panels. This presents the opportunity for electric shock injury to anyone who comes into contact with an energised portion of the vehicle. Investigators should check that the internal power pack has been isolated or removed. Many EVs have integrated emergency circuit breakers (known

as pyro fuses) that activate when a collision is detected, or a cut-loop feature that can be manually pulled or cut to disconnect high-voltage systems if required. The battery, however, retains its charge and the electrical circuits can remain live for some time. Do not touch any bright orange cabling or parts (see Figure 15).



Figure 15. Highlighted parts that may pose an electrical hazard under an EV's bonnet

- b) Unexpected movement – An “active” EV may have no engine noise but be capable of moving at any time. Accidental pressure on the accelerator may cause the vehicle to unexpectedly accelerate forward or backwards. EVs can also be operated remotely via a phone or key fob, either accidentally or intentionally. On many models, the dash is illuminated when the vehicle is “ready” (Figure 16); these lights may flash or change colour if there is a fault. However, this varies from vehicle to vehicle. Some, for example, have no on/off button and will be ready to drive once the doors are unlocked. To avoid this, any keys should be stored or retained at least 15 meters away from the vehicle. Wheels should be ‘checked’.



Figure 16. Dashboard of an HEV

- c) Thermal runaway – Damage to a lithium-ion battery (either due to a manufacturing fault or subsequent damage) can lead to a situation in which heat builds up within a battery cell to the point that a self-sustaining reaction occurs (Held *et al.*, 2022; Mallick and Gayen. 2023; Zhang *et al.*, 2024). This can lead to an explosion and sustained, very high-heat fires. Do not approach an EV or HEV if it is popping, whistling, emitting vapour, or on fire.
- d) Overturned vehicles – Due to the presence of a large battery pack, the centre of gravity of an EV/HEV may not be where the investigator expects it to be, and the vehicle may be more likely to fall over, with the potential for injury to the investigator. Upright or overturned EVs should be secured in place if they are to be examined prior to recovery.

In all instances, to mitigate the potential for harm, FIs should conduct their own dynamic risk assessment in addition to any assessments made by Police, Fire Service, or

vehicle recovery specialists. FIs should follow their local practices for the recovery and retention of EVs / HEVs. Until it is ascertained that vehicles are safe to examine, they should only be approached using the guidance in Figure 17:

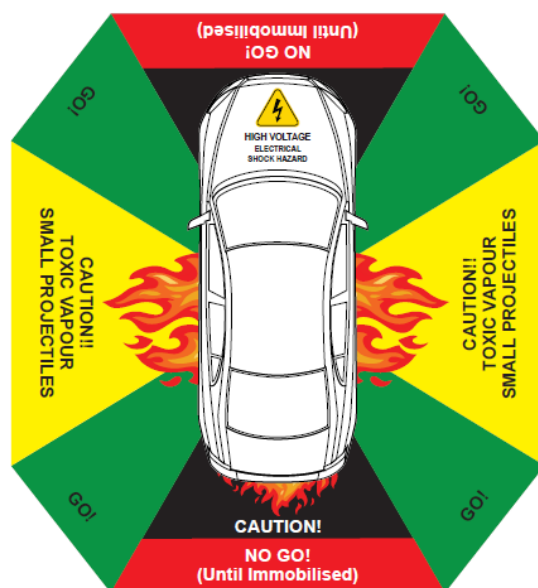


Figure 17. Guidance on when not to approach a fire-damaged EV or HEV

10.3 Investigation Process

Following the identification and mitigation of risks, the fire investigation should proceed in accordance with the methodology described elsewhere within this BPM. The investigation should seek to determine the area(s) of origin and cause of the fire through a systematic process of observation, documentation, excavation, and reconstruction. The requirements for the investigation of electrical fires, as set out within the main body of this BPM, should also be applied where relevant.

Consideration should be given to the following:

a) External Examination:

- Examine the body panels for fire damage, burn patterns, oxidation effects, deformation, impact damage, and any evidence of tool marks or tampering.
- Assess the condition of exterior trim, bumpers, wheel assemblies, tyres, lighting units, charging ports, and other external components for evidence relevant to fire development or cause.
- Examine glazing, window frames, and window mechanisms to determine, where possible, the position and condition of windows and other openings at the time of the fire.
- Record any evidence of collision damage, forced entry, deliberate interference, or post-fire disturbance.

b) Internal Examination:

- Examine all relevant vehicle compartments, including the engine compartment, passenger compartment, luggage compartment, battery compartment, and any other storage areas.
- Assess fire patterns, directional indicators, heat and smoke effects, and areas of differential damage in the same manner as for any other vehicle fire investigation.

- Where competent and authorised to do so, examine wiring looms, electrical distribution systems, connectors, power sources, battery systems, control modules, and associated components for evidence of electrical activity, failure, or fire involvement.
 - Consider the condition and location of safety-critical systems, including battery management systems, high-voltage isolation devices, and electrical protection systems, where applicable.
- c) Additional Observations:
- Look for and record the presence of any extraneous items that may be relevant to the origin, development, or cause of the fire.
 - Consider whether the location, condition, or nature of any such items is consistent with accidental, deliberate, or unrelated circumstances.
 - Record and recover any items considered significant to the investigation in accordance with established evidence-handling procedures.

10.4 Extra Considerations

The FI should consider the following additional factors when investigating fires involving electric vehicles (EVs), hybrid electric vehicles (HEVs), or other vehicles equipped with lithium-ion batteries.

10.4.1 Burn Patterns

- Lithium-ion battery packs are often designed to vent heat, gases, and combustion products downward and away from the passenger compartment.
- Where a fire originates within the battery pack, the passenger compartment may remain comparatively undamaged despite extensive damage elsewhere on the vehicle.
- Fires involving lithium-ion battery packs can burn at higher temperatures and for longer durations than many conventional vehicle fires. Consequently, the overall extent of damage may be greater than would normally be expected in a comparable internal combustion engine vehicle fire.
- Some manufacturers recommend tilting or raising the vehicle, often to approximately 30°, to facilitate inspection of the underside of the battery pack housing. The FI should recognise that such actions may displace items and affect the interpretation of burn patterns.

10.4.2 Fire-fighting Activity

- Firefighting tactics employed by responding fire and rescue personnel should be considered when interpreting damage patterns.
- Some fire and rescue services may use a piercing nozzle, lance, or similar specialist equipment to gain direct access to the battery pack. Damage resulting from such intervention should be identified and distinguished from fire-related damage where possible.

10.4.3 Electrical Examination

- The pyrotechnic safety device (commonly referred to as a pyrotechnic disconnect or pyro fuse) should be examined to determine whether it has operated. Its status may provide information regarding the occurrence of a collision, impact event, or other safety-system activation. Manufacturer guidance should be consulted when interpreting any findings.
- Recovery, handling, dismantling, or examination of a lithium-ion battery pack, high-voltage system, or associated cabling should only be undertaken by personnel who are trained and competent to do so.

- Where appropriate, assistance should be sought from a suitably qualified electrical engineer or high-voltage vehicle specialist.

10.4.4 Digital evidence

- Vehicle telematics and event data should be considered as potential sources of evidence. Data may be stored locally within vehicle systems or remotely via cloud-based services and may provide information concerning battery performance, charging activity, fault conditions, vehicle operation, and events leading up to the fire.
- The recovery and interpretation of such data may require specialist equipment and expertise.
- Depending on the condition of the vehicle and the nature of the investigation, digital evidence may require prioritisation due to the risk of data loss or system degradation.
- Where remote acquisition is not possible, the process of recovering digital evidence may involve destructive examination or may adversely affect other lines of enquiry.
- The FI should be aware that interaction with the vehicle during examination, such as opening doors, activating controls, or reconnecting systems, may alter or overwrite electronic records.

10.4.5 Collision damage

- Where collision damage is present or suspected, consideration should be given to consulting a suitably qualified collision investigator to assess the significance of vehicle deformation and impact-related failures.

10.4.6 Charging System and Infrastructure

- Consideration should be given to the possibility of faults associated with the charging process, charging equipment, or charging infrastructure.
- The charging station most recently used by the vehicle, as well as any charging stations habitually used, should be identified and considered as part of the investigation.
- Examination of charging equipment, charging cables, and associated electrical infrastructure should only be undertaken by appropriately qualified and competent personnel.

10.4.7 Vehicle History and Supporting Information

- Relevant risk assessments, vehicle recovery records, and recovery facility assessments should be obtained where available.
- Consideration should be given to any vehicle recalls, known technical defects, previous fault reports, statutory roadworthiness inspection records, maintenance history, repairs, modifications, or alterations that may be relevant to the fire.
- Accounts of recent vehicle use and activity should be obtained from the driver, owner, operator, witnesses, or other relevant persons where practicable.
- The FI should consider seeking assistance from specialist electric vehicle engineers or manufacturer representatives where the circumstances of the fire warrant such involvement.
- Relevant technical information should be obtained from the vehicle manufacturer wherever possible, including wiring diagrams, battery specifications, battery-management-system information, safety-system details, and recovery procedures.

10.4.8 Further Reference Material

For additional guidance on the investigation of fires involving electric and alternative-fuel vehicles, the FI may wish to consult recognised training and technical resources, including the relevant modules available through CFITrainer.net and other nationally recognised fire investigation programmes.

10.5 Considerations for investigation of lithium-ion battery fires (excluding vehicles)

Due to the wide range of products that incorporate lithium-ion batteries, whether removable or integrated, it is not practical to provide specific guidance for every battery type, device, or application. This section therefore sets out general principles and considerations to assist the FI when investigating fires involving lithium-ion batteries.

- The FI should apply the general principles for determining the area of origin and cause of fire as detailed within the main body of this BPM.
- Electrical assessments and examinations should only be undertaken to the extent that the FI is trained, competent, and authorised to do so. The FI should recognise the limits of their expertise and seek assistance from a suitably qualified Forensic Electrical Engineer or another specialist where appropriate.
- Wherever possible, the manufacturer, make, model, serial number, and relevant specifications of any electrical appliance, equipment, charger, or lithium-ion battery involved should be identified and recorded.
- Consideration should be given to the design and operation of any safety features incorporated within the battery or device, such as battery management systems (BMS), thermal protection devices, current-limiting devices, pressure-relief vents, and protective circuitry. The FI should seek to determine whether any such features have operated and what significance this may have to the investigation.
- Lithium-ion batteries should not be dismantled, disassembled, or subjected to invasive examination unless this is undertaken by personnel who are appropriately trained, competent, and equipped to do so.
- The FI should not work on, handle, or remain in close proximity to lithium-ion batteries that exhibit signs of thermal instability, including overheating, swelling, venting, vapour release, hissing, whistling, popping sounds, smoke production, or other indications of thermal runaway.
- Consideration should be given to researching any product recalls, safety notices, technical bulletins, known defects, previous fire incidents, or safety concerns associated with the appliance, charger, or battery under investigation.
- The charging history of the battery should be considered, including the timing of recent charging activity, the charger used, charging location, charging duration, and any reported charging anomalies.
- Any charger, charging cable, adaptor, power supply unit, extension lead, or associated charging equipment should be examined and assessed for relevance to the fire, where appropriate.
- The FI should consider liaison with manufacturers, battery specialists, testing laboratories, certification bodies, or other relevant technical experts where specialist knowledge may assist the investigation.
- The location, condition, and position of batteries, battery components, chargers, and associated debris should be carefully documented before any disturbance, recovery, or examination is undertaken.
- Consideration should be given to the recovery, packaging, transportation, storage, and disposal requirements for damaged lithium-ion batteries, recognising that they may present ongoing fire, chemical, or re-ignition hazards.

- The retention and storage of appliances or items containing lithium-ion batteries should be undertaken in accordance with applicable legislation, organisational procedures, and local safety protocols.
- Where laboratory examination is required, consideration should be given to preserving the integrity of the battery, associated electronics, and any potential electronic or diagnostic data that may assist in determining the cause of the fire.

11. OTHER TRANSPORTATION VEHICLES

The process for investigating fires/explosions involving other types of transportation vehicles is, in general, an extension of the methodologies already described in this BPM. The FI could be examining a train carriage, bus, tram, truck, military/agricultural vehicles/machinery, recreational vehicle, sea vessel, or aircraft cabin, but the fundamental principles of fire investigation remain the same. Where an incident involves highly specialised/sophisticated/unusual vehicle systems due to the nature of their fuel, propulsion, cooling, energy storage, electronic vehicle management systems, etc., beyond the experience of the original FI, then input from professionals with the requisite specialist knowledge will be required to assist in such investigations.

APPENDIX E – EXPLOSION INVESTIGATIONS

In addition to the guidance provided elsewhere within this BPM, the information contained in this Appendix is intended to assist the FI in the investigation of explosions. The principles and methodologies described should be considered alongside the general procedures for scene examination, evidence recovery, origin determination, and cause investigation set out in the main body of this BPM.

While many of the fundamental principles of fire investigation are equally applicable to explosion investigations, explosions can present additional complexities relating to scene preservation, damage interpretation, evidence recovery, and hazard assessment (Strehlow and Baker, 1975; Guban, 1979; Harris, 1983; Hattwig and Steen, 2004; Molnárné, Schendler and Schröder, 2008; Beveridge, 2011). The guidance contained within this Appendix is intended to support the FI in recognising, assessing, and investigating such incidents.

1. RESOURCES

Explosion investigations require specialised knowledge and expertise. Accordingly, such investigations should be led by an FI who possesses the requisite training, knowledge, skills, and experience. Further information regarding competency requirements is provided in [Section 4.1](#).

Depending on the nature, complexity, and scale of the incident, the lead FI may be supported by additional fire investigators and other specialist personnel. This may include, as appropriate, gas engineers, process engineers, explosives specialists, structural engineers, forensic scientists, electrical engineers, and other subject matter experts. It is recognised that the availability and level of specialist expertise may vary between jurisdictions.

A key responsibility of the FI is to maintain and, where necessary, enhance the measures implemented by first responders to preserve the scene and protect evidence. In addition, and commensurate with their level of competence and authority, the FI may:

- collect and evaluate detailed information concerning the scene, the explosion effects, and the circumstances surrounding the incident
- for explosions occurring in occupational or industrial environments, give particular consideration:
 - compliance with requirements relating to the safety and health protection of workers potentially at risk from explosive atmospheres, including the classification of hazardous zones and areas, where applicable (European Commission, 1997, 1999, 2009, 2014).
 - relevant risk assessments, permits-to-work, safe systems of work, operating procedures, maintenance records, occupational logs, and other workplace documentation
- obtain and preserve data from process control systems, safety management systems, distributed control systems (DCS), supervisory control and data acquisition (SCADA) systems, alarm logs, event records, and other relevant electronic data source
- create a comprehensive and accurate record of the scene using appropriate documentation techniques and technologies, including photography, videography, laser scanning, LiDAR, photogrammetry, aerial imagery, unmanned aerial systems (UAS), and other suitable mapping or recording methods
- identify and secure specialist technical resources required to safely examine, recover, preserve, and interpret evidence
- coordinate with relevant regulatory authorities, infrastructure operators, emergency services, and technical specialists to obtain information relevant to the investigation
- ensure that scene examination and evidence recovery activities are appropriately planned and conducted to minimise disturbance of fragile or transient evidence

2. METHODS

2.1 Gathering of information

The FI should identify and record the details of all witnesses, occupants, operators, first responders, and injured persons who may possess information relevant to the incident. Witnesses should be interviewed, where appropriate, and their accounts accurately recorded in accordance with applicable procedures.

The FI should also document their own observations and seek information relating to the circumstances immediately preceding the explosion. Consideration should be given to the following:

- The identity, location, and actions of witnesses, occupants, and injured persons before, during, and immediately after the explosion.
- The accounts provided by witnesses regarding unusual observations, such as noises, odours, smoke, vibration, equipment malfunction, process upsets, electrical disturbances, or other abnormal conditions.
- The location and condition of casualties, where relevant to the investigation.
- Photographic and video documentation of the scene, surrounding area, points of access and egress, and, where appropriate and proportionate, the location of witnesses and bystanders present at the time of the incident.
- Prevailing weather and environmental conditions, including temperature, wind speed and direction, precipitation, humidity, and atmospheric pressure, where relevant.
- The construction, layout, occupancy, and use of affected buildings or structures, including details of materials, services, alterations, and structural features that may have influenced the explosion effects.
- The nature and distribution of the contents of the premises, including the presence, use, storage, or handling of combustible gases, flammable liquids, combustible dusts, hazardous materials, explosives, or other substances capable of contributing to the incident.
- The presence and condition of utilities and services, including natural gas, liquefied petroleum gas (LPG), electrical systems, compressed gases, fuel systems, process equipment, and ventilation systems.
- Any changes in operating conditions, production activities, maintenance activities, process parameters, equipment status, or other technical processes that occurred shortly before the explosion.
- Any alarms, warnings, equipment faults, shutdowns, safety-system activations, or unusual events reported prior to the explosion.
- All information obtained should be assessed in conjunction with the physical evidence and other investigative findings to assist in determining the circumstances, origin, and cause of the explosion.

2.2 Liaison

Upon arrival at the scene, the FI should liaise with the first responder and other relevant personnel to obtain an overview of the incident, establish the current situation, identify existing and potential hazards, and ensure that appropriate scene preservation measures remain in place. The FI should also establish contact with the officer or person responsible for overall scene management and coordinate investigative activities accordingly.

Attention should be given to the following:

- identify all relevant stakeholders, interested parties, command structures, and lines of communication
- identify actual and potential hazards and undertake appropriate risk assessments. This should include consideration of scene stability, hazardous materials, utilities, unexploded materials, environmental conditions, and the selection and use of suitable personal protective equipment (PPE)
- risk information should be communicated to all relevant personnel present at the scene in accordance with applicable legal and organisational requirements
- conduct, as far as practicable, an initial assessment of all accessible areas of the scene to gain an overview of the incident and identify areas requiring specialist examination
- undertake a preliminary assessment of the nature and extent of damage, together with an initial evaluation of the type and characteristics of the explosion
- agree and document an investigation strategy that is proportionate to the circumstances of the incident, including:
 - resource requirements, including personnel, specialist expertise, equipment, time, and logistical support
 - roles, responsibilities, and reporting arrangements
 - measures for the identification, preservation, recovery, and continuity of physical, trace, and forensic evidence, including biological material, ignitable liquid residues, and other potentially significant deposits or contaminants
 - scene documentation requirements, including photography, videography, aerial imagery where appropriate, scene mapping, sketches, measurements, laser scanning, and contemporaneous notes
 - priorities for scene examination, evidence recovery, and specialist support
 - establish procedures for the exchange of information between investigators, emergency responders, technical specialists, and other agencies involved in the investigation

The first responder should continue to liaise with and assist the FI and any specialist personnel as appropriate, particularly in relation to scene preservation, safety management, and the provision of information gathered during the initial response.

2.3 Health and Safety

The safety of personnel and the preservation of evidence should remain paramount throughout the investigation. Unnecessary access to the scene should be prevented and, where practicable, the area should be secured using appropriate cordons and access-control measures.

The FI should undertake a dynamic risk assessment on arrival and continuously review hazards as the investigation progresses.

Consideration should be given to the following:

- Provide first aid or other immediate assistance within the limits of personal competence and training, and take reasonable measures to prevent further injury to casualties, responders, investigators, and members of the public.
- Assess the stability and condition of affected structures and identify potential overhead and structural hazards, including damaged masonry, roof coverings,

ceilings, staircases, chimneys, walls, floors, glazing, and other components that may collapse, fall, or otherwise present a risk.

- Restrict access to unsafe areas until they have been assessed and declared safe by appropriately qualified personnel.

2.3.1 Identification and Management of Hazards

The FI should identify actual and potential hazards and seek specialist assistance where appropriate. This may include consultation with:

- Explosive Ordnance Disposal (EOD) personnel or other explosives specialists.
- Structural engineers, building surveyors, or other suitably qualified professionals.
- Representatives of utility providers, including gas, electricity, water, telecommunications, and other infrastructure operators.
- Hazardous materials (HAZMAT) specialists and other technical advisers as required.

The FI should ensure, so far as reasonably practicable, that:

- Gas, electrical, and other utility supplies have been isolated, made safe, or otherwise controlled by authorised and competent persons.
- Appropriate atmospheric monitoring has been undertaken where there is a risk of flammable, toxic, or oxygen-deficient atmospheres.
- Buildings, rooms, voids, or enclosed spaces are ventilated where necessary and where it is safe and appropriate to do so.

2.3.2 Additional Hazards

The FI should consider the presence of additional hazards, including:

- Equipment that could inadvertently create an ignition source, such as electrical equipment, portable tools, communications devices, vehicles, or other apparatus capable of generating sparks, heat, or static electricity, particularly where flammable gases, vapours, dusts, or explosive atmospheres may still be present.
- Hazardous chemicals, toxic substances, corrosives, oxidisers, or other dangerous materials (ECHA, 2024).
- Biological hazards, including contamination from human remains, bodily fluids, medical waste, contaminated water, or other biohazardous materials.
- Radioactive substances or sources of ionising radiation.
- Asbestos-containing materials and other hazardous construction products.
- The risk of secondary explosions arising from:
 - The release of flammable gases from LPG cylinders, pressure vessels, tanks, or pipework.
 - The leakage of flammable or ignitable liquids, such as petrol, solvents, thinners, or fuels.
 - The failure, rupture, or violent heating of gas cylinders, pressure vessels, or containers exposed to fire conditions fire (see section on [BLEVE](#) later in this appendix).
 - Dust explosions caused by the disturbance of combustible dust deposits.
- Unexploded incendiary devices or incendiary materials.

- Improvised explosive devices (IEDs), booby traps, secondary devices, or other intentional hazards that may have been placed to harm responders or investigators.
- Sharp objects, damaged metalwork, broken glass, and debris that may present physical injury risks.
- Environmental hazards, including adverse weather conditions, unstable ground, flooding, confined spaces, and water-filled excavations.

2.4 Scene Examination and Investigation Strategy

Hazards should be reviewed continuously throughout the investigation. The FI should assess the full extent of the scene and establish the boundaries of the affected area, including the outer perimeter. The direction and method of examination should be determined at an early stage. Depending on the nature of the incident and investigative objectives, the examination may proceed either from the perimeter towards the suspected seat of the explosion or from the centre outwards. All personnel involved in the investigation should agree upon and understand the chosen approach.

The FI should gather and assess information from all available sources, including:

- CCTV and other video recordings
- fire detection, intrusion detection, and alarm systems
- process monitoring systems and electronic records
- witness accounts and first responder observations
- photographs, videos, plans, and other scene documentation

The scene should be examined in detail, taking into account:

- the dimensions and configuration of the affected area
- damage distribution and directional indicators
- blast effects and debris distribution
- fire patterns, where fire is associated with the explosion
- structural damage and patterns of failure

The FI should seek to identify and classify the type of explosion involved. Consideration should be given to, among others:

- explosions involving flammable gas-air mixtures
- explosions involving ignitable liquid vapour-air mixtures
- condensed-phase explosions
- physical explosions resulting from the rupture of pressurised vessels or equipment
- Boiling Liquid Expanding Vapour Explosions (BLEVEs)

Alternative explanations should be systematically evaluated and, where appropriate, excluded on the basis of the available evidence.

Following the preliminary assessment, an investigation strategy should be developed and documented. Where necessary, specialist advice should be sought from appropriately qualified personnel, such as gas engineers, heating system specialists, explosives experts, structural engineers, or other relevant subject matter experts.

Witnesses should be interviewed as appropriate, recognising that additional information may become available as the investigation progresses. Witness accounts should be accurately recorded and, where required, formal statements obtained in accordance with applicable legal and organisational procedures.

All observations and investigative activities should be documented comprehensively through contemporaneous notes, sketches, plans, photography, videography, measurements, and other appropriate recording methods.

Where appropriate and safe to do so, systems or equipment relevant to the investigation should be examined and tested in situ before removal. Samples should be collected where necessary to support laboratory examination and hypothesis testing. Suitable reference samples should also be obtained wherever practicable.

The FI should undertake the systematic excavation and examination of debris in areas of interest. The recovery of evidence and collection of samples should be documented sequentially, with continuity maintained throughout the process.

Consideration should be given to:

- reconstruction of damaged systems, equipment, structures, or scenes where this may assist interpretation
- the taking of measurements and preparation of scaled plans
- the collection of additional information from relevant organisations, manufacturers, regulators, or technical specialists
- the ongoing review of investigative findings and development of working hypotheses
- the preservation of the scene for any further examinations that may be necessary.

The FI should seek to establish, as far as reasonably practicable, the sequence of events leading to the explosion based upon all available physical evidence, witness testimony, technical information, and analytical findings.

2.4.1 Specific Considerations for Physical Explosions

Where a physical explosion is suspected, the FI should consider:

- examination of the pressure vessel and associated components, including fittings, regulators, valves, gauges, pipework, and safety devices
- determination of the vessel's design specifications, service history, inspection records, and operating parameters
- the need for specialist metallurgical examination to identify material defects, fatigue, corrosion, overheating, or mechanical failure
- evaluation of any heating processes, thermal inputs, or abnormal operating conditions that may have contributed to vessel failure

2.4.2 Further Research

The FI should consider obtaining additional information concerning:

- the physical and chemical properties of the material or substance involved
- the intended storage, handling, transportation, and use of the material
- previous incidents, published case studies, technical literature, safety alerts, recalls, or other relevant information relating to similar events

2.4.3 Experimentation and Analysis

Where appropriate, consideration may be given to:

- the development and testing of investigative hypotheses
- experimental or empirical assessment of proposed failure mechanisms
- engineering, thermodynamic, blast, or fire calculations
- computer modelling and simulation to assist in evaluating potential scenarios and explosion effects

2.4.4 Circumstances of the Incident

Particular consideration should be given to factors that may have influenced the occurrence of the explosion, including:

- deviations from normal operating procedures, practices, or conditions
- decent changes to equipment, processes, materials, maintenance arrangements, or operational activities
- human factors, including actions, decisions, training, competence, supervision, communication, and procedural compliance
- environmental factors, including weather conditions, temperature, ventilation, occupancy, and other external influences.

2.5 Handling of Items

The preservation of the scene and the protection of evidence should be a primary consideration throughout the investigation. Wherever practicable, items should remain in their original location and condition until they have been examined, documented, and assessed for evidential significance. Where circumstances require the movement, removal, or alteration of any item, the action taken, the reason for it, and the item's original position should be contemporaneously recorded.

Access to the scene should be controlled and monitored through the use of a scene log or equivalent recording system, documenting all persons entering or leaving the scene and the purpose of their attendance.

The FI should take reasonable measures to prevent unnecessary disturbance, damage, loss, or contamination of evidence. Unless required for safety reasons or authorised investigative purposes, materials, equipment, appliances, switches, valves, controls, and other potentially significant items should not be operated, moved, or altered.

Consideration should be given to the following:

- maintain the integrity of the scene by preventing unnecessary access and restricting activities that may disturb evidence
- establish and maintain a scene log recording all entries to and exits from the scene
- ensure that any movement, removal, or alteration of items is appropriately authorised, documented, and, where necessary, photographed before and after the action
- avoid unnecessary handling of evidence and use appropriate methods to minimise contamination
- preserve the relationship between items, debris, structures, and other physical evidence wherever possible
- prevent further damage to the scene resulting from investigative activities, recovery operations, weather conditions, or unauthorised access
- refrain from operating or manipulating switches, valves, controls, appliances, or equipment unless this is necessary for safety, examination, or testing and has been appropriately documented
- ensure that continuity and chain-of-custody procedures are maintained for all recovered exhibits.

Where fatalities have occurred, deceased persons should normally remain in situ until authorised recovery is undertaken. The FI should coordinate with the relevant investigative, forensic, and medico-legal authorities and, where appropriate, a Disaster Victim Identification (DVI) team or equivalent specialist resource.

The FI should take appropriate measures to protect evidence from deterioration caused by environmental conditions, including wind, rain, flooding, sunlight, temperature fluctuations, and human activity. Evidential material may include both visible evidence, such as debris, structural components, fragmentation, and glass fragments, and latent evidence, such as explosive residues, accelerant residues, fingerprints, DNA, and trace materials.

Where necessary, significant items or areas of evidence should be protected using suitable coverings, shelters, tents, awnings, or other protective measures designed to minimise loss, contamination, or degradation.

Any essential removal of debris, structural elements, or other items should be coordinated with all relevant investigators and specialists. Such actions should be fully documented, including the rationale, method used, personnel involved, and the location from which items were removed.

See also [Section 5.4 “Initial Scene Preservation”](#) and [Section 8 “Handling Items”](#).

2.6 Sampling and documentation

All sampling, test, and experimental methods should be fully documented and, where practicable, validated. The design and execution of any investigation should consider factors including sampling strategy, precision, bias, measurement uncertainty, detection limits, sensitivity, and the suitability of the methods under the prevailing environmental conditions.

For example, in investigations involving diffuse-phase explosions (including gas, vapour, mist, dust, or mixed fuel-air explosions), it may be necessary to undertake the following activities:

- analyse representative samples, as appropriate, to identify:
 - the gas involved
 - the ignitable liquid involved
 - the dust involved
- examine items recovered from the scene, such as:
 - pipes
 - hoses
 - cylinders
 - regulators
 - valves
 - electrical equipment or devices
 - clothing and footwear
- where necessary, conduct further testing to obtain information relevant to the investigation, such as:
 - flash point of the ignitable liquid (Cooke and Ide, 1985; Kanury, 1990)
 - distribution of dust particles
 - electrical conductivity
 - evidence of mechanical overheating
 - ignition source energy
 - ignition source temperature

The objective of sampling, examination, and testing is to obtain reliable and scientifically defensible evidence that supports the identification of the fuel involved, the ignition source, the explosion mechanism, and any contributory factors relevant to the incident.

3. SOURCE OF IGNITION

Throughout the investigation, an open-minded and systematic approach should be maintained, ensuring that all plausible ignition sources are identified, considered, and evaluated against the available evidence.

Flammable mixtures of gases, vapours, mists, or dusts (Bartknecht and Zwahlen, 1989) with air or oxygen may be ignited by a range of ignition sources, including:

- open flames
- mechanically generated sparks
- electrical sparks and arcs
- electrostatic discharge sparks
- hot surfaces

The likelihood that a particular ignition source initiated the event should be assessed in the context of the fuel involved, the environmental conditions, and the minimum ignition energy and temperature characteristics of the explosive atmosphere.

Investigators should also be aware that certain commonly suspected ignition sources may be incapable of igniting many flammable atmospheres. For example, glowing tobacco products generally do not ignite mixtures of hydrocarbons and air, including common fuels such as propane and petrol vapour (Jewell, Thomas and Dodds, 2011; Marcus and Geiman, 2014). However, some flammable gases and liquids, such as acetylene, hydrogen sulphide and diethyl ether, possess sufficiently low ignition energy requirements to be ignited by glowing tobacco under specific conditions (Holleyhead, 1996). Consequently, the role of smoking materials should be evaluated based on the properties of the fuel involved and the circumstances of the incident rather than assumed either to be a likely or unlikely source of ignition.

The identification and assessment of potential ignition sources should be supported, where appropriate, by examination of physical evidence, witness accounts, testing, reconstruction, and scientific analysis to establish whether the source was capable of igniting the explosive atmosphere present at the time of the incident.

4. EFFECTS FROM DIFFERENT TYPES OF EXPLOSIONS

Explosions can cause damage through a combination of blast overpressure, thermal effects, fragmentation, and the displacement of materials. The nature and extent of the damage depend on factors such as the type and quantity of fuel involved, the degree of confinement, the location of the explosion, and the surrounding environment.

The primary effects of an explosion are typically associated with:

- blast overpressure, which can cause structural damage, displace objects, and injure people through the action of pressure waves
- thermal effects, resulting from the combustion process, which may cause burns, ignition of combustible materials, and fire spread

In addition to these primary effects, explosions may generate secondary hazards, including:

- fragmentation, where components of plant, equipment, containers, or structures are broken apart and projected at high velocity
- debris and rubble projection, which can cause significant damage or injury upon impact
- secondary fires or explosions, arising from the release and ignition of additional combustible materials

Careful examination of damage patterns can assist in determining the origin and development of the explosion. Directional indicators, such as the displacement of debris, deformation of

structural elements, fragment trajectories, soot deposition, and blast loading effects, may help investigators identify the probable seat or centre of the explosion. However, such indicators should be interpreted cautiously and in conjunction with other evidence, as blast wave reflections, structural collapse, and post-explosion activities can alter or obscure the original damage patterns.

The assessment of explosion effects should therefore form part of a systematic investigation that integrates scene examination, witness evidence, physical artefacts, analytical testing, and scientific interpretation to establish the nature, origin, and consequences of the event.

4.1 Diffused-phase explosions

Diffuse-phase explosions are characterised by the absence of a clearly defined seat of explosion and by widespread damage over a relatively large area. Typical effects may include damage to windows, doors, walls, ceilings, roofs, and other building elements resulting from the propagation of a pressure wave through an enclosed or partially enclosed space.

The formation and dispersion of an explosive atmosphere may be influenced by:

- diffusion
- gravitation
- thermal convection
- turbulence

Additional factors that may affect the development and distribution of a diffuse-phase explosive atmosphere include:

- density of the fuel relative to air
- thermal inputs and outputs within the system or enclosure

The resulting damage patterns are often less localised than those associated with condensed-phase explosions, and investigators may need to rely on indicators such as fuel distribution, ventilation conditions, witness accounts, and blast effects to determine the origin and development of the event.

4.2 Condensed-phase explosions

Condensed-phase explosions involve energetic materials that are present in a condensed state, such as solid or liquid explosives. These explosions are typically characterised by:

- well-defined and localised damage
- the possible presence of a crater or seat of explosion
- high-velocity penetration of nearby materials
- fragmentation effects
- extensive shattering or pulverisation of surrounding materials

The damage caused by condensed-phase explosions is generally concentrated around the point of initiation and may provide clear physical indicators of the explosion origin.

4.3 Physical explosions

Physical explosions result from the sudden release of stored physical energy, typically through the rupture of a pressurised vessel caused by vessel failure and/or excessive internal pressure. Although no combustion reaction is required, the effects can be severe.

Physical explosions may produce damage comparable to that caused by high explosives where a rapid phase transition occurs, resulting in the spontaneous vaporisation of an overheated liquid. This phenomenon is commonly referred to as a Boiling Liquid Expanding Vapour Explosion (BLEVE).

4.4 Boiling Liquid Expanding Vapour Explosions (BLEVEs)

A Boiling Liquid Expanding Vapour Explosion (BLEVE) (Abbasi and Abbasi, 2006; Baraza, 2023) occurs when a vessel containing a liquid above its atmospheric boiling point experiences catastrophic failure, resulting in rapid depressurisation and expansion of the liquid and vapour contents.

BLEVEs may occur with or without combustion, depending on the nature of the material contained within the vessel:

- a **hot BLEVE** involves a flammable substance and is typically accompanied by ignition of the released vapour, producing a fireball
- a **cold BLEVE** involves a non-flammable substance and results primarily from the physical effects of rapid expansion and vessel rupture

A BLEVE generally requires the following sequence of events:

- i. The liquid is heated, resulting in rapid vapour generation and increasing internal pressure.
- ii. Excess vapour may be released through a pressure-relief device, if fitted.
- iii. Continued heating weakens the vessel, which ultimately fails at its weakest point, such as a welded seam.
- iv. Loss of containment causes sudden depressurisation.
- v. Rapid expansion of the liquid and vapour occurs.
- vi. In a **cold BLEVE**, the expansion of vapour and vessel fragmentation produce the explosion effects.
- vii. In a **hot BLEVE**, the released vapour mixes with air and is ignited, producing a fireball in addition to blast and fragmentation effects.

Examples include:

- the rupture of an overheated domestic or industrial hot-water storage vessel, which may result in a cold BLEVE
- the failure of an LPG cylinder exposed to fire, which may result in a hot BLEVE

BLEVEs have also occurred following traffic collisions involving road tankers transporting flammable liquids or liquefied gases. In such incidents, the combination of vessel rupture, blast overpressure, thermal radiation, and projectile hazards can result in extensive damage and significant risks to emergency responders and the public.

Typical thermal radiation levels associated with BLEVE fireballs have been reported in the range of approximately 200 to 350 kW/m², capable of causing severe thermal damage and life-threatening injuries at considerable distances from the source.

4.5 Investigation Considerations

Correctly distinguishing between diffuse-phase, condensed-phase, physical, and BLEVE events is essential for determining the origin and cause of an explosion. Investigators should evaluate the nature of the damage, the distribution of debris, evidence of fuel involvement, vessel integrity, witness observations, and any available physical or analytical evidence when identifying the type of explosion and reconstructing the sequence of events.

5. DENSITY AND BUOYANCY OF GASES AND VAPOURS

The density and buoyancy characteristics of gases and vapours can significantly influence their dispersion, accumulation, and the formation of flammable atmospheres. Understanding these effects is important when assessing the origin, development, and extent of a gas or vapour cloud associated with an explosion or fire incident.

In general, gases or vapours with a density greater than that of air (relative density > 1) tend to sink and accumulate in low-lying areas, such as basements, pits, drains, trenches, and other confined spaces. Conversely, gases or vapours with a density lower than that of air (relative density < 1) tend to rise and accumulate near ceilings, roof spaces, or elevated structures.

However, this behaviour applies primarily where concentration gradients exist and the atmosphere is not fully mixed. In practice, buoyancy is governed by the density differences between neighbouring regions of the gas-air mixture rather than solely by the molecular or molar mass of the gas itself. As a result, the movement of gases and vapours depends on factors such as:

- concentration gradients
- temperature differences
- ventilation conditions
- air currents
- turbulence
- the geometry of the enclosure or environment

Once a gas or vapour becomes uniformly mixed with air, the resulting homogeneous atmosphere will not separate into its constituent components to any significant extent under gravity alone within the dimensions typically encountered in buildings or industrial premises. Consequently, the distribution of a flammable atmosphere is often governed more by mixing and ventilation processes than by the relative density of the gas or vapour itself.

When investigating gas- or vapour-related incidents, consideration should therefore be given to:

- the physical properties of the released substance
- the likely release location and release rate
- ventilation pathways and airflow patterns
- the presence of confined, low-lying, or elevated spaces where flammable concentrations could accumulate
- environmental conditions at the time of the incident

An understanding of these factors can assist investigators in reconstructing the dispersion of flammable atmospheres, identifying potential ignition locations, and evaluating the sequence of events that led to the incident.

6. BOILING POINT AND VAPOUR PRESSURE

The boiling point and vapour pressure of a liquid are important physical properties that influence its ability to generate flammable vapours and, consequently, its potential involvement in a fire or explosion.

The **boiling point** of a liquid is the temperature at which its equilibrium vapour pressure equals the surrounding atmospheric pressure. At this temperature, vapour formation occurs throughout the liquid, resulting in boiling. Mixtures of flammable liquids generally exhibit a **boiling range** rather than a single boiling point because their individual components evaporate at different temperatures.

Vapour pressure is a measure of a liquid's tendency to vaporise at a given temperature. Liquids with higher vapour pressures generate flammable vapours more readily and can therefore form ignitable atmospheres more easily than liquids with lower vapour pressures under the same conditions. Vapour pressure generally increases with temperature, leading to increased vapour generation as a liquid becomes warmer.

The **evaporation rate** provides a practical indication of how rapidly a liquid evaporates when exposed to the atmosphere. It is commonly expressed relative to a reference substance, such as diethyl ether or *n*-butyl acetate. For mixtures of flammable liquids, evaporation rates can vary significantly depending on the composition of the mixture and the volatility of its individual components.

When assessing the behaviour of ignitable liquids, investigators should recognise that the actual evaporation rate may differ substantially from published values because it is influenced by several factors, including:

- the exposed surface area of the liquid
- the surface-area-to-volume or surface-area-to-mass ratio
- ambient temperature and pressure
- air movement and ventilation
- the nature of the surface or substrate on which the liquid is present
- absorption into porous materials
- wick effects, where porous materials increase the effective evaporative surface area

These factors can affect both the rate of vapour generation and the persistence of flammable vapours within an environment. Consequently, the evaporation characteristics of an ignitable liquid should be assessed in the context of the specific conditions that existed at the time of the incident rather than relying solely on published physical property data.

An understanding of boiling point, vapour pressure, and evaporation behaviour can assist investigators in evaluating the likelihood of flammable atmosphere formation, estimating the extent of vapour dispersion, and reconstructing the circumstances leading to a fire or explosion.

7. FLASHPOINT AND EXPLOSIVE LIMITS

The **flash point** is the lowest temperature at which a material or product emits sufficient vapour to form an ignitable mixture with air that will ignite momentarily when exposed to an ignition source under specified test conditions. Flash point values can vary significantly depending on the test method employed, particularly whether an **open-cup** or **closed-cup** procedure is used. For the assessment of fire and explosion hazards, closed-cup methods, such as those specified in **ISO 2719** (ISO, 2025e) and **ISO 13736** (ISO, 2021), are generally preferred because they more closely simulate conditions in which vapours may accumulate within enclosed or partially enclosed spaces.

The **Lower Explosive Limit (LEL)**, also referred to as the **Lower Flammable Limit (LFL)**, is the lowest concentration of a flammable gas or vapour in air that is capable of propagating combustion when exposed to an ignition source. Below the LEL, the mixture is considered too lean to burn because insufficient fuel is present to sustain combustion.

The **Upper Explosive Limit (UEL)**, also referred to as the **Upper Flammable Limit (UFL)**, is the highest concentration of a flammable gas or vapour in air that is capable of propagating combustion when exposed to an ignition source. Above the UEL, the mixture is considered too rich to burn because insufficient oxygen is available to support combustion.

The region between the LEL and UEL defines the **flammable (or explosive) range**, within which a gas-air or vapour-air mixture may be ignited if a sufficiently energetic ignition source is present. The explosive limits of a substance are influenced by several factors, including:

- temperature
- pressure
- vapour concentration
- oxygen concentration
- the presence of inert or diluent gases

An increase in temperature generally broadens the flammable range by lowering the LEL and increasing the UEL, thereby increasing the likelihood of ignition.

The **Minimum Ignition Energy (MIE)** is the lowest amount of energy required to ignite a flammable atmosphere under specified conditions. Ignition may result from a variety of sources, including:

- electrical sparks or arcs
- electrostatic discharges
- frictional or mechanically generated sparks
- hot-working activities
- other energetic ignition sources

The MIE varies considerably between substances and is influenced by factors such as fuel concentration, pressure, temperature, turbulence, and the composition of the surrounding atmosphere. Materials with very low MIE values can be ignited by relatively weak ignition sources, including electrostatic discharges that may not be perceptible to personnel.

An understanding of flash point, explosive limits, and minimum ignition energy is essential when assessing the potential for ignition, evaluating the significance of suspected ignition sources, and reconstructing the sequence of events leading to a fire or explosion incident. These properties should be considered alongside environmental conditions, fuel distribution, confinement, and ventilation when determining the likelihood of ignition and subsequent flame propagation.

8. AUTO-IGNITION TEMPERATURE

The **autoignition temperature (AIT)** is the lowest temperature at which a combustible substance ignites spontaneously in air without the application of an external ignition source, such as a spark or flame. Auto-ignition temperature is an important parameter in the assessment of fire and explosion hazards; however, it is highly dependent on the test method and conditions under which it is determined. A commonly used method for measuring autoignition temperature is specified in **ASTM E659** (ASTM, 2015).

Investigators should recognise that published auto-ignition temperatures are obtained under controlled laboratory conditions and may not accurately represent ignition behaviour in real-

world environments. The actual temperature required for ignition can be influenced by numerous factors, including:

- exposure time
- surface geometry and size
- airflow and ventilation conditions
- pressure
- fuel concentration
- the thermal properties of the contacting surface

Consequently, ignition by hot surfaces often requires temperatures substantially higher than published auto-ignition temperatures, particularly where the period of contact between the fuel-air mixture and the heated surface is short.

The ease with which a substance can be ignited also depends on the type of ignition source. Different substances can exhibit markedly different responses to spark ignition, hot-surface ignition, flames, frictional heating, or electrostatic discharge. For example, hydrogen has a very low minimum ignition energy and can be readily ignited by weak sparks, yet it requires a comparatively high temperature for autoignition. Accordingly, the likelihood of ignition should be evaluated in relation to the specific ignition mechanism under consideration rather than by reference to a single ignition property alone.

Particular care should be taken when assessing the potential role of smoking materials as an ignition source. Experimental evidence indicates that only a limited number of substances can be ignited by smouldering tobacco products (Holleyhead, 1996). Examples include:

- carbon disulfide
- hydrogen
- acetylene
- ethylene oxide
- phosphine (hydrogen phosphide)
- hydrogen sulphide
- diethyl ether

In contrast, common hydrocarbon fuels such as propane and petrol vapour are not known to be readily ignited by smouldering tobacco products under normal conditions (Jewell, Thomas and Dodds, 2011; Marcus and Geiman, 2014). Consequently, smoking materials should neither be automatically assumed nor automatically excluded as a potential ignition source. Their significance should be assessed in the context of the fuel involved, the environmental conditions, and the available physical and scientific evidence.

When evaluating potential ignition mechanisms, investigators should consider auto-ignition temperature, minimum ignition energy, ignition source characteristics, fuel concentration, confinement, and exposure conditions collectively, as these factors determine whether ignition was feasible under the circumstances of the incident.

9. PROCESSING A CONDENSED-PHASE EXPLOSION SCENE

The investigation of condensed-phase explosions generally follows the same fundamental principles and methodology as those applied to diffuse-phase explosions. However, condensed-phase incidents often differ significantly in terms of scale, severity of damage, complexity of the scene, and the level of specialist resources required. Consequently, such investigations may involve multiple agencies and specialist personnel.

When dealing with condensed-phase explosions, it is essential that personnel with appropriate expertise are involved from the earliest stages of the response and investigation (Thurman,

2017). Safety considerations are paramount due to the potential presence of unexploded explosive devices, secondary devices, unstable explosive materials, or hazardous remnants.

Accordingly, specialist explosive ordnance personnel, such as Explosive Ordnance Disposal (EOD) teams, police bomb disposal units, military explosive specialists, or other suitably qualified experts, should be deployed as necessary to identify, assess, render safe, and remove any explosive hazards. The examination of the scene should not commence until the area has been declared safe by the responsible authority (Leiber, 2003).

Once the scene has been assessed and declared safe, the investigation may proceed in accordance with the general principles and procedures described elsewhere in this BPM.

9.1 Scene Examination

A systematic and documented search strategy should be employed to identify, recover, and preserve evidential material. The search area may extend well beyond the immediate seat of the explosion owing to the effects of blast overpressure, fragmentation, and debris projection. Search boundaries should therefore be determined based on the likely blast radius, damage patterns, witness information, and any available intelligence.

Attention should be given to the identification and recovery of:

- unexploded devices or components that have been rendered safe
- fragments and remnants of exploded devices
- evidence of initiation systems
- residues of explosive materials
- items that may assist in determining the construction, deployment, and function of the device

9.2 Potential Evidential Materials

Items of evidential significance may include, but are not limited to:

- explosive substances and explosive residues
- detonators, initiators, and blasting caps
- electrical components, such as cables, wires, connectors, switches, and terminals
- electronic components, including printed circuit boards, timers, microcontrollers, and remote-control receivers
- power sources, such as batteries, battery packs, and associated circuitry
- mobile telephones, pagers, radio-frequency devices, or other equipment capable of remote initiation
- fragments of containers, casings, packaging materials, or concealment devices
- mechanical components associated with triggering mechanisms
- toolmarks, fingerprints, DNA, or other forensic evidence associated with device construction or deployment (Marshall and Oxley, 2008)

9.3 Reconstruction and Analysis

Where practicable, recovered components should be documented, photographed, mapped, and examined to facilitate reconstruction of the device. Reconstruction may assist in determining:

- the type of explosive material used
- the initiation method
- the sequence of operation of the device
- the degree of sophistication involved in its construction

- potential links to other incidents, individuals, or organisations

Analysis of explosive residues and device components should be undertaken using validated scientific methods and interpreted by appropriately qualified specialists.

9.4 Investigation Considerations

The investigation of condensed-phase explosions should integrate scene examination, forensic analysis, witness evidence, intelligence information, and specialist technical assessment. Emphasis should be placed on maintaining scene integrity, preserving evidential continuity, and ensuring that all recovered materials are handled in accordance with established safety and evidential procedures.

The objective of the investigation is to determine the nature of the explosive event, identify the explosive material and initiation mechanism involved, establish the origin and cause of the explosion, and support any subsequent criminal, regulatory, or safety-related proceedings.

Please refer to [Appendix G](#) – “Clandestine Manufacture of Drugs and Explosives” and the ENFSI BPM “for the Forensic Recovery, Identification and Analysis of Explosives Traces”, for further information.

10. AREA OR POINT OF ORIGIN

Explosions can cause damage to both the immediate and surrounding areas through the combined effects of blast overpressure and thermal energy. The severity and distribution of damage are influenced by factors such as the quantity and type of fuel, the degree of confinement, the rate of combustion, and the geometry of the environment.

For deflagrative explosions, the theoretical maximum explosion pressure is achieved when the fuel-air mixture is both homogeneous and at, or close to, the stoichiometric concentration. In practice, such conditions are uncommon because flammable atmospheres are often unevenly distributed, affected by ventilation, obstacles, temperature gradients, and variations in fuel concentration. Nevertheless, even where the volume of the explosive atmosphere represents only a small proportion of the total building volume, the resulting damage may be extensive.

Determining the **area or point of origin** is a fundamental objective of the investigation. The probable centre of the explosion may be identified through the systematic examination of directional indicators, including:

- displacement of walls
- movement or deformation of doors and windows
- failure patterns in ceilings and roofs
- fragment trajectories
- distribution of debris
- structural deformation caused by blast loading

The use of vector diagrams or other methods of damage pattern analysis may assist investigators in visualising the direction and magnitude of blast forces and, consequently, in identifying the most likely origin of the explosion. However, damage patterns should be interpreted with caution, as secondary collapses, reflected pressure waves, and post-incident disturbances can modify the original scene.

When evaluating blast effects, investigators should recognise that published maximum pressure data generally relate to **deflagration** phenomena. In some circumstances, a **deflagration-to-detonation transition (DDT)** may occur, producing substantially higher

pressures and more severe damage. The characteristics of the observed damage may therefore assist in determining whether the event involved a deflagration, a detonation, or a transition between the two.

Prediction of blast pressures, particularly in detonation events, can be challenging because of the numerous variables involved, including confinement, geometry, fuel distribution, turbulence, and environmental conditions (Kinney and Graham, 1985). Additional phenomena that may influence pressure development and damage patterns include:

- **pressure piling** between interconnected compartments or volumes
- flame and pressure-wave propagation through ducts, channels, and pipework
- reflection and amplification of pressure waves from solid surfaces
- pressure accumulation at dead ends or confined sections of piping systems

While mathematical modelling and pressure calculations may provide useful information, their results should be interpreted carefully and validated against the physical evidence wherever possible. The large number of unknown variables associated with real incidents can limit the reliability of theoretical calculations if used in isolation.

In addition to blast effects, investigators should consider the role of thermal effects. The extent of heat damage is influenced by both the **heat flux density** and the **duration of heat exposure**. Assessment of thermal damage, including burning patterns, material degradation, and fire spread, may provide valuable information regarding the location, intensity, and development of the explosion and any associated fire.

The determination of the area or point of origin should therefore be based on the integration of scene observations, damage pattern analysis, witness information, scientific testing, and engineering judgement. No single indicator should be relied upon in isolation, and all available evidence should be considered collectively when reconstructing the sequence of events.

APPENDIX F - INVESTIGATING FIRE SCENES WITH FATALITIES

1. INTRODUCTION

When human remains are found or suspected of being within a fire scene their recovery must be undertaken by specialist practitioners (such as anthropologists) who have the competence to do so. The entire body must be recovered. This is particularly challenging when the body has undergone a level of cremation such that limbs, bones and bone fragments can become dissociated from the body and/or when there has been animal activity on the deceased's remains.

While body recovery is a specialist area, all fire scene investigators must be aware of how such remains should be preserved and protected during the fire scene investigation.

2. HEALTH AND SAFETY

There are several specific hazards associated with the recovery of human remains at a fire scene. These vary in type and severity depending on the degree of damage to the body and the scene.

The hazards specifically related to the body investigation may include ergonomic (e.g. manual handling and lifting), biological hazards (e.g. from released bodily fluids), sharp hazards (e.g. exposed bone fragments), and psychological trauma. However, the FI must also remain vigilant about the wider scene hazards.

Full personal protective equipment, including masks and goggles, must be worn for biological and physical hazards identified. Professional counselling must be available for anyone who encounters human remains.

2.1 Ergonomic

The FI may be involved in examining the body, assisting with lifting or turning the deceased. The area to work in may be confined, preventing the adoption of correct manual handling techniques.

2.2 Sharps

As a result of the fire, a body may have been exposed to both heat and impact damage, for example, due to fallen debris and structural collapse. Loss of soft tissue due to heat can expose fractured bone which, in turn, pose a risk to cut or puncture wounds for those handling the remains.

2.3 Biological hazards

Soft tissue damage can expose internal organs and bodily fluids, which may contain potentially harmful, infectious bacteria and viruses; these, in turn, pose a risk to those handling the remains, both by inhalation and by direct contact. The FI must take special precautions when examining fatalities where there has been a positive confirmation for infectious disease or it can be reasonably suspected from the lifestyle of the deceased.

2.4 Psychological hazards

Observing and handling human remains can often lead to psychological distress, the effects of which may be immediate or may remain latent. It is advisable that whenever the FI has been affected by a scene with a body, they seek help and professional counselling through their organisation and the medical services in their country.

3. GENERAL INDICATORS OF THE PRESENCE OF HUMAN REMAINS

The physical condition of human remains will vary depending on the severity of the fire and/or the length of time the body has been exposed to the heat flux within the fire scene. Heat and firefighting activities can cause extensive fragmentation and dispersion of the remains. However, those remains will still be present within the scene and they will need to be recovered. The stages of damage to human remains are listed below; they 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/or exposure of the skull
- extensive loss of soft tissue, fragmentation of limb bones, exposure and fragmentation of skull and/or ribs, some loss of tissue and fragmentation of torso
- complete loss of soft tissue and fragmentation of bones, those left may disintegrate to powder/ash upon 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 location and recovery of human remains within the FI's jurisdiction should be initiated, and the scene should be re-evaluated for hazards and processing. Consultation with the appropriate specialist must be part of this re-evaluation process; specialists might include a forensic pathologist/anthropologist, a cadaver dog team, etc.

In cases where the recovery of human remains is required, the following procedures should be followed:

- a) The location of the body, including nearby debris on or around the body and protected areas under or near the body, must be recorded along with a measured plan/sketch of the immediate vicinity.
- b) The body's position and orientation must be recorded.
- c) The image capture of teeth and fingerprints should be considered before handling the body, depending on its condition and the requirements of the case.
- d) Handling of the remains must be kept to a minimum.
- e) Based on the condition of the body and the agreed scene examination strategy, samples (e.g. fingernail scrapings, biological evidence, trace evidence, clothing, etc.) may be taken in situ (Blackledge, 2007). 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.
- f) Personal possessions and any clothing or materials associated with the body must be imaged and documented in situ prior to their recovery, packaging, and labelling. Any expected clothing that is absent should be documented. If items cannot be easily recovered, such as a lighter in the deceased's hand, record this and ensure that the forensic pathologist and/or the investigating team are aware.
- g) Document the level of heat/burn damage to the different areas of the body.
- h) Ante mortem damage to the body such as possible knife wounds and gunshot wounds should be recorded. Further specialist advice may be required.

- i) Excavation of the area around the body is preferable before removing it. Determining which level of debris, the body is at may help determine the sequence of events.
- j) Where applicable the body should be turned over within the scene and imaged. Document the level of heat/burn and other damage to the underside of the body.
- k) The area underneath the body should be recorded, carefully excavated, and may be analysed for possible ignitable liquids and other trace evidence.
- l) For bodies that have become fragmented, the fragments may be displaced as a result of fire suppression activities, and all attempts should be made to maximise their recovery. In such cases, consultation with forensic anthropologists or forensic pathologists is advisable. Discussing fire suppression activities with the first responders may help in this respect. The location of all fragments must be recorded before recovery.
- m) Animal activity can also disperse body parts. Every effort should be made to locate all body parts within the scene.
- n) For situations where bones are exposed and have become fragile through heat exposure, stabilising chemicals or wrapping materials, such as cling film, may 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 exhibited.
- o) Body fragments can adhere to other debris, and this debris should be carefully checked before removal from the scene.
- p) In scenes where human remains are in danger of further damage and the body cannot be recovered quickly, it is the responsibility of the investigating team to initiate contact with the appropriate specialists as soon as possible and act upon their advice to protect and preserve the remains.
- q) Human remains must be placed in cold storage as soon as possible after recovery.

APPENDIX G – CLANDESTINE MANUFACTURE OF DRUGS AND EXPLOSIVES

1. DRUGS LABORATORY

1.1 Introduction

A clandestine laboratory is any laboratory or facility that illegally manufactures controlled substances or converts precursor chemicals into controlled substances (SWGDRUG, 2014). This includes the production of stimulants, depressants, hallucinogens and narcotics, (e.g. methamphetamine, amphetamine, heroin, cannabis), as well as an ever-changing number of controlled analogues and designer substances collectively known as New Psychoactive Substances (e.g. substituted cathinones, synthetic cannabinoids). It also includes chemical processes that convert precursor chemicals (e.g., APAAN) into precursor chemicals.

Clandestine laboratory premises can be encountered in almost any location, usually in houses, garages, industrial buildings, warehouses, motor vehicles, and caravans. The chemical processes use equipment and recipes of varying degrees of sophistication. Many of the chemicals found at a clandestine laboratory have a wide range of legal uses from which they have been diverted.

Cannabis has traditionally been grown outdoors, but there has been an increasing trend toward indoor cultivation. This can be found in domestic or commercial premises and can be located in closets, basements, etc. depending on the scale and sophistication of the production. Indoor cultivation is often hydroponic, where plant nutrients and water are supplied to the growing medium.

1.2 Health and Safety

It is critical for all responders at the scene to be able to identify the levels of risk and the types of protection needed for the particular incident under investigation. Full personal protective equipment (including breathing apparatus) for chemical hazards must be worn based on the scale of the production process and the nature of the chemical or biological hazards identified. Based on the identified hazards, appropriate decontamination procedures must be implemented.

Clandestine laboratories pose specific and serious health threats (James, 1989; Norman, Ciesielski and Wagner, 2021).

1.3 Chemicals

There are many hazardous, highly flammable chemicals (e.g. large amounts of solvents), explosive and corrosive chemicals (e.g. strong acids and bases), as well as toxic and carcinogenic substances. These pose immediate and long-term risks to human health and the environment. Dangers also arise when chemical waste mixtures are present, and chemical spills can result in inhalation of toxic levels of solvents, acids, cyanide, etc. Additional dangers arise from a lack of control measures, unlabelled or mislabelled chemicals, and inappropriate ventilation within the 'laboratory', which can increase the risk to responders. See Flowchart A (below in this appendix) for examples of chemicals used in the synthesis of various controlled drugs and Flowchart C (below) for examples of common household products used in the synthesis of methamphetamine.

1.4 Structural modifications

Premises are often modified to facilitate laboratory operations. This may increase the risk to building integrity and reduce ventilation by removing or altering supporting structures. Poor ventilation can increase the risk of inhaling chemicals, as well as high humidity levels, which can result in elevated airborne mould spore levels posing potential health hazards, e.g. respiratory diseases.

Gas and electricity supplies may be altered, increasing the risk of fire, explosion, and electrocution. Modifications to water supplies may pose a risk due to reduced water flow or chemical contamination.

1.5 Equipment

Homemade or modified equipment can result in catastrophic failure, increasing the risk of explosion and fire. The presence of gas cylinders increases the risk of explosion and fire. Carbon dioxide generators are utilised in cannabis cultivation and pose a risk of suffocation. See Flowchart B (below) for examples of equipment commonly used in the synthesis of various controlled drugs.

1.6 Booby Traps

All responders should be aware of the possible presence of booby traps, such as (but not limited to) electrified metal plates at door thresholds, wiring door and window handles to mains electricity supplies and the use of sharp objects strategically placed at entry points.

1.7 General Indicators

Indicators which may alert FIs to the possible presence of a clandestine laboratory during the initial assessment may include the following:

- unusual odours such as solvents, ammonia, etc.
- covered or painted over windows
- unusual or excessive security measures for the type of premises e.g. cameras, high fences, locked/chained gates, bars on windows, guard dogs, booby traps
- laboratory glassware and equipment
- chemicals, marked and unmarked chemical containers, unusual amounts of cold remedies
- unusual use or location of heating, cooling or pressurised equipment
- unusual ventilation equipment (e.g. pipes, ducts, fans, etc.)
- large amounts of full and/or empty chemical containers kept inside or in the vicinity of the premises
- observation by neighbours of odours, smoke, and waste dumping
- evidence of cooking rings and burnt utensils
- chemical and/or oil spillages and stains on surfaces
- unusual, stained coffee filters
- discarded cling film and foil
- drug recipe books and notes (handwritten and printed)
- internet references for drug production

Some specific equipment associated with the cultivation of cannabis include:

- growing medium, e.g. clay pebbles, perlite, coco shell, rockwool
- seeds
- germinating discs

- nutrients, fertiliser, vitamins, minerals and/or pesticides
- pH meters
- electrical conductivity meters
- thermometers
- carbon dioxide cylinders/generators
- extractor fans
- ventilation ducting
- carbon filters
- light bulbs, e.g. neon, LED, silver halide, high pressure sodium
- light reflectors
- electrical timers
- extensive wiring
- aluminum foil sheeting for lining walls and ceilings
- watering system, e.g. drip feed system with associated piping, capillary mats, misters, water pump, etc.
- written instructions on cultivation process including watering, lighting and feeding
- various pots and trays
- plant and growing medium waste

1.8 Scene Evaluation

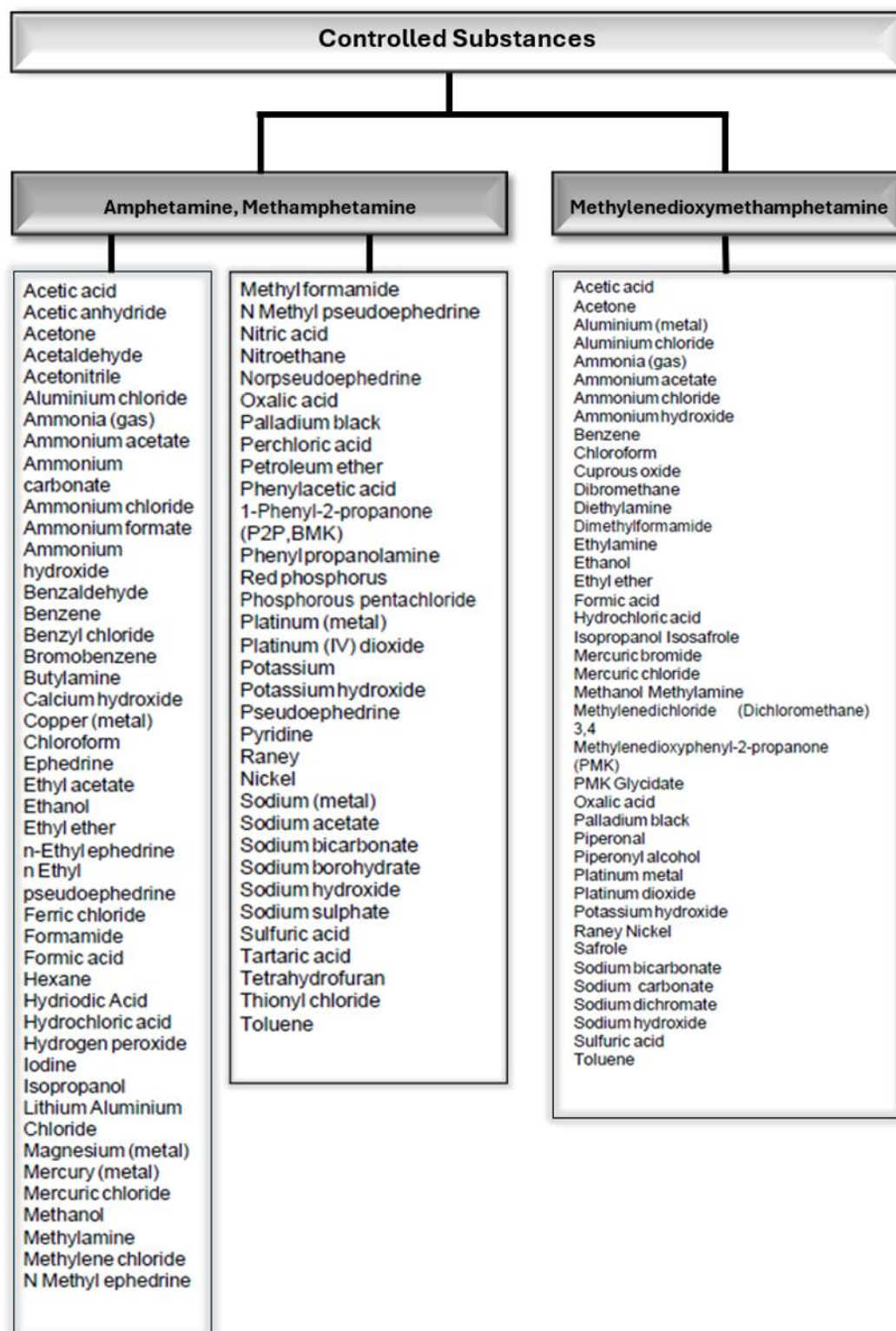
If a clandestine manufacturing process is suspected at any stage of the scene examination, standard operating procedures for handling hazardous materials must be initiated, and the risks and scene processing must be re-evaluated. Consultation with the appropriate specialists must be part of this re-evaluation process.

In addition to the fire investigation, a separate scene investigation may be carried out to investigate the chemical manufacturing process. This will involve appropriate specialists which may include forensic chemists, safety officers, environmental officers and decontamination and clean-up personnel, etc.

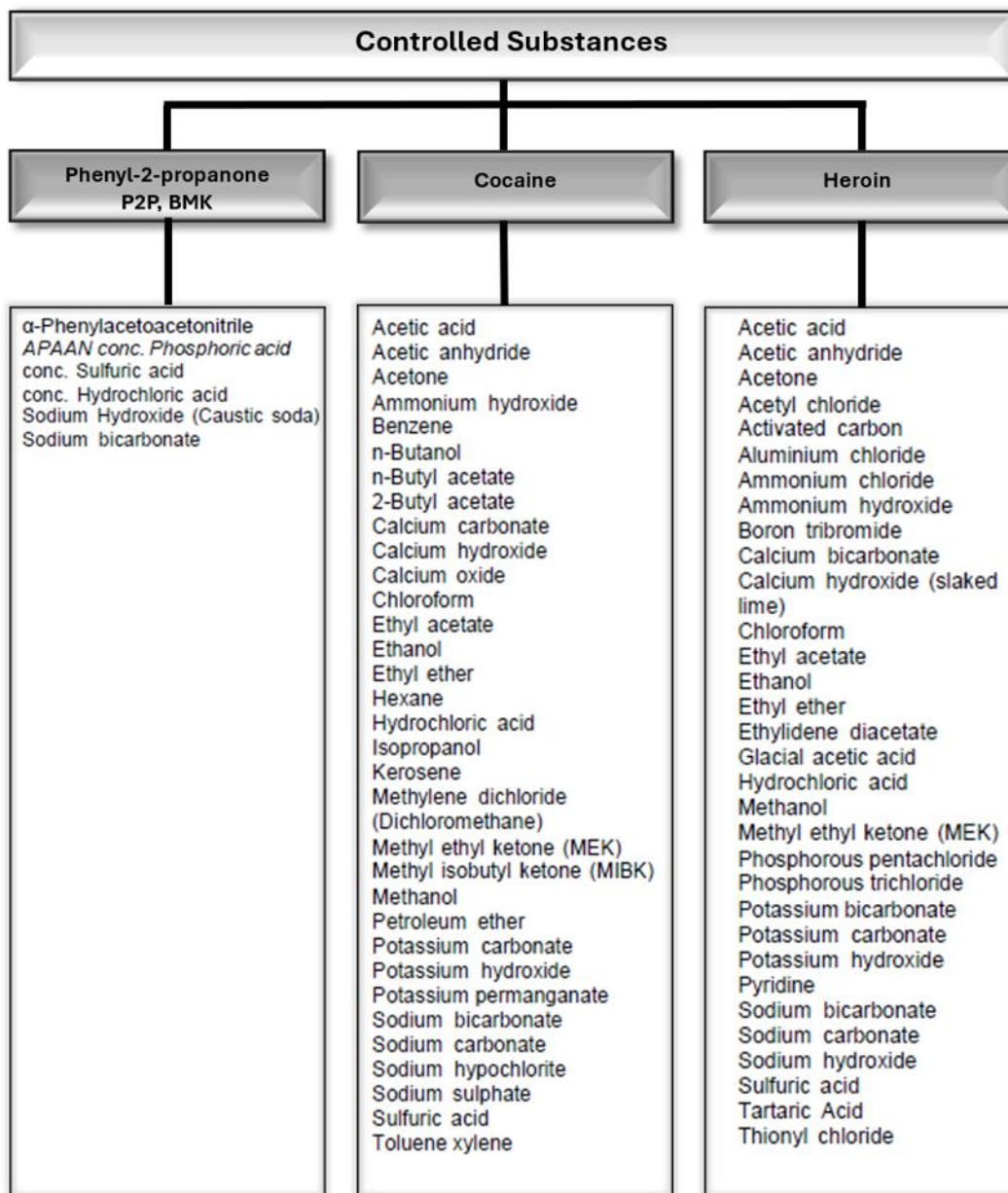
An overall strategy should be discussed and agreed upon prior to any activities commencing in relation to both the fire scene investigation and the investigation of the chemical manufacturing process. This must include (but is not limited to):

- scene preservation, including restricting access to the scene
- health and safety, including managing the chemical or biological hazards present
- evacuation of the immediate area or extension of a 'safe zone'
- safe shut down of any chemical processes in operation
- identification of the chemical process involved where possible
- prioritisation of the scene examination in order to maximise the recovery of relevant evidence for both the fire scene investigation and the investigation of the clandestine laboratory
- it may be possible to detect illegal drugs in fire debris from clandestine laboratories (Green, Kuk and Wagner, 2017)

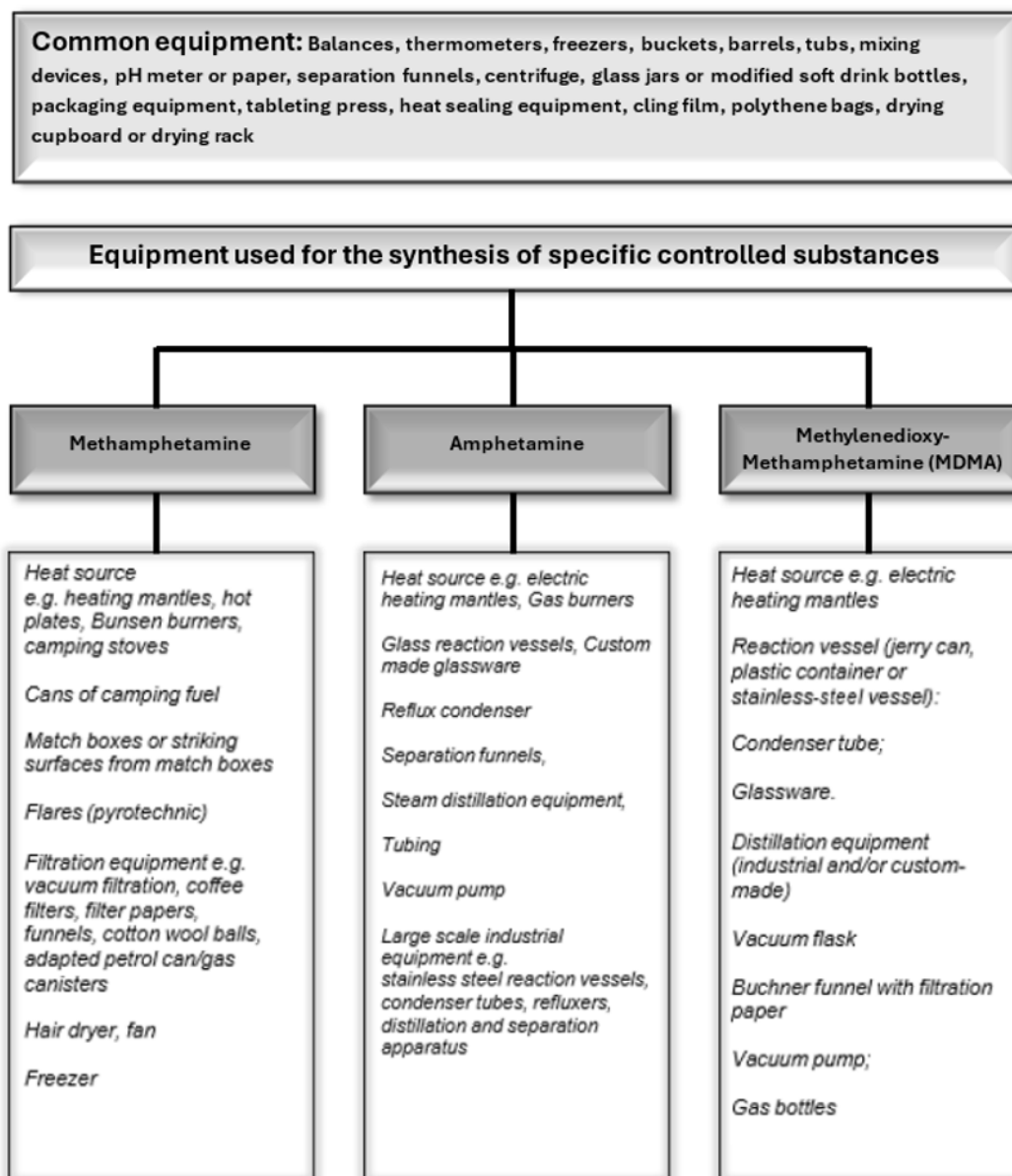
FLOWCHART A. CHEMICALS USED IN THE SYNTHESIS OF CONTROLLED DRUG SUBSTANCES.



FLOWCHART A (CONTINUED). CHEMICALS USED IN THE SYNTHESIS OF CONTROLLED DRUG SUBSTANCES.



FLOWCHART B: EQUIPMENT COMMONLY USED FOR THE SYNTHESIS OF CONTROLLED DRUG SUBSTANCES



FLOWCHART C: HOUSEHOLD PRODUCTS COMMONLY USED FOR THE SYNTHESIS OF METHAMPHETAMINE

Household products	Chemical
Precursor source Weight loss products, Cold medication e.g. Sudafed, Plant material Vasoconstrictor Source of Essential chemicals Aluminum foil Photographic development solvent Lithium batteries Matchbooks and matchbook striker surface Iodine tinctures Etching solvent, wood preserver Hair bleach Food preservative Precious metals, jewellery, dentistry Table salt Epsom salt, fertilizer Source of Solvents Mineral spirits Charcoal lighter fluid Camping fuel Denatured alcohol Nail varnish remover Paint remover Methylated spirit Air conditioning refrigerant, crop fertilizer Antifreeze Dyes, lacquers, varnish Engine starter fluid Gas line, antifreeze, brake cleaner fluid Lye, drain cleaner, caustic soda Paint thinner, brake cleaner Concrete cleaner Concrete cleaner, disinfectant Battery acid Dry cleaning fluid Vinegar	Precursor chemicals Ephedrine/Pseudoephedrine Ephedra Phenylpropanolamine Essential chemicals Aluminum foil Methylamine Lithium Red phosphorous Iodine Mercuric chloride Hydrogen peroxide Phosphinic acid Platinum Sodium chloride Magnesium sulfate Solvents Mineral spirits Charcoal lighter fluid Camping fuel Ethanol Acetone Dichloromethane Methylated spirit Anhydrous ammonia Ethylene glycol, propylene glycol Benzene Ethyl ether Methanol Sodium hydroxide Toluene Hydrochloric acid Hydriodic acid Sulfuric acid Trichloroethylene Acetic acid

2. HOMEMADE EXPLOSIVES

2.1 Introduction

Explosive materials include conventional high explosives, quantities of small arms propellant, fireworks, other pyrotechnic materials, incendiary mixtures and homemade explosive mixtures.

Explosives are sensitive to heat, shock, friction, and electrostatic discharge; sensitivity varies depending on the type of explosive. However, they all can explode violently if mishandled. Some homemade explosives may be manufactured in a cold-water bath or stored in a refrigerator or packed in ice to ensure they remain inert and stable.

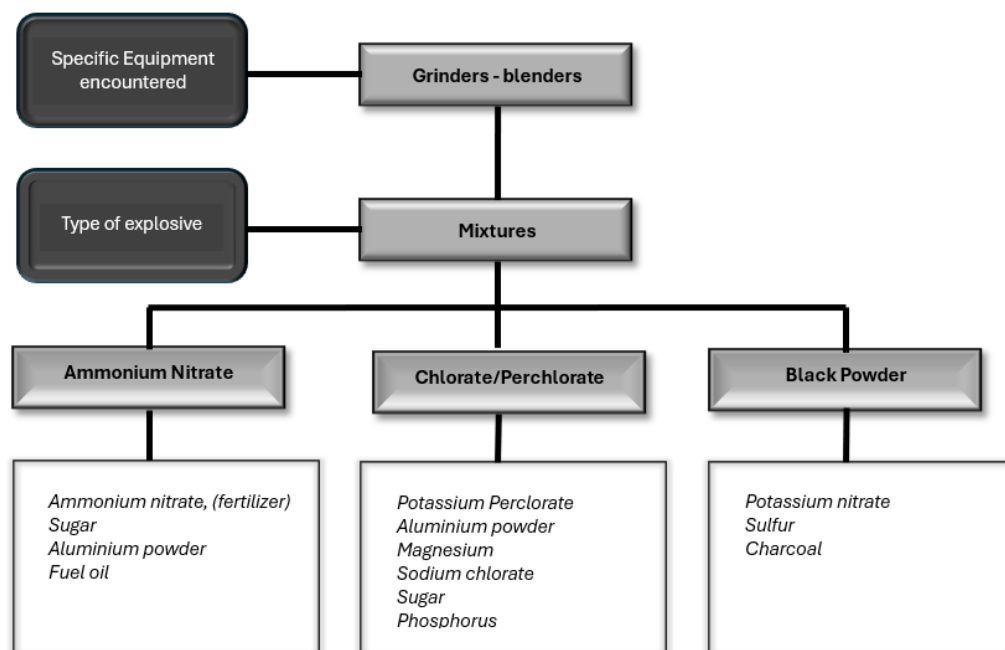
Homemade explosives can be made from commonly available chemicals. They can be more or less sensitive than commercial explosives, depending on the formulation, starting materials, purity, and methods of manufacture.

Many chemicals can be obtained from chemical companies in pure form or from readily available household or industrial products. Flowcharts D and E below provide examples of commonly encountered chemicals used in the manufacture of homemade explosives, together with their physical appearances.

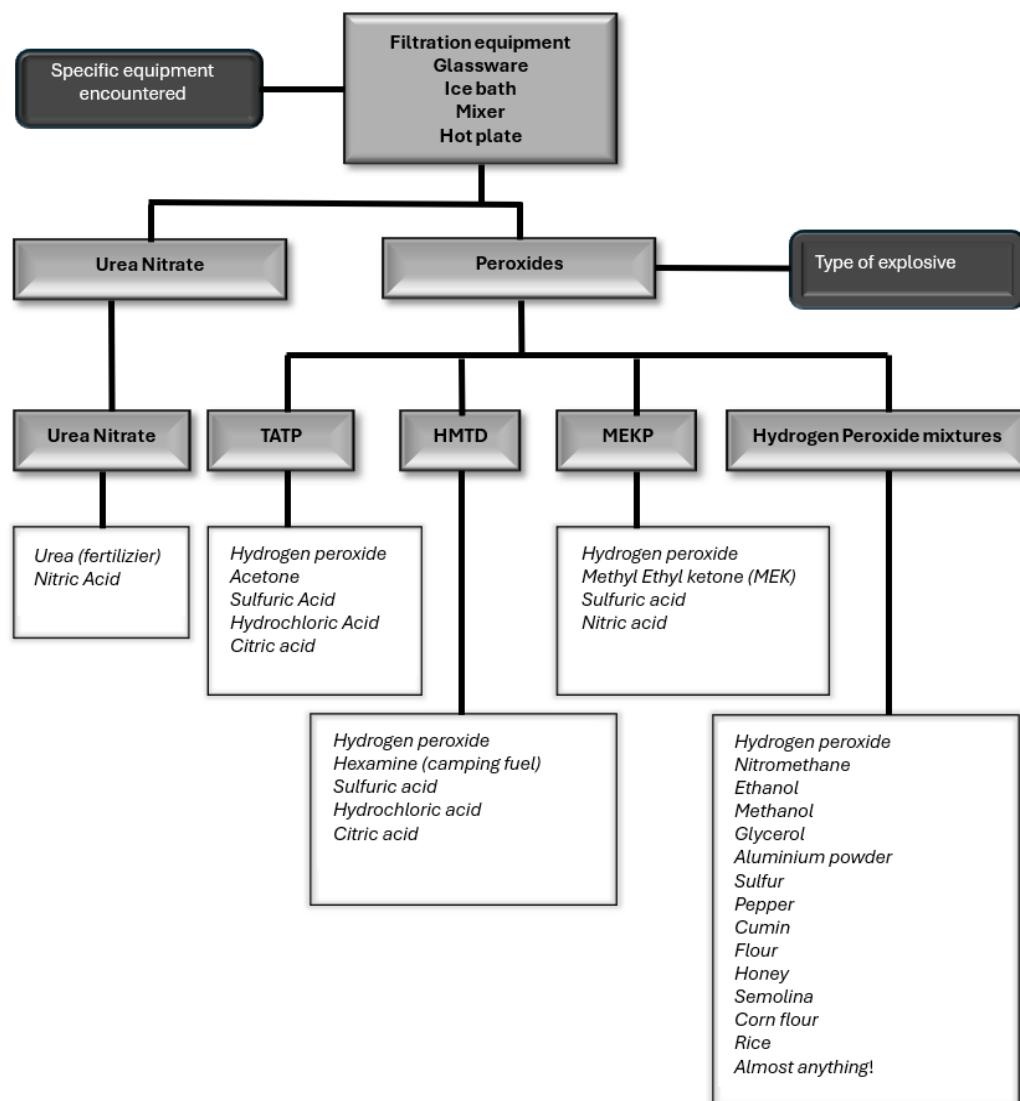
Some homemade explosives may be found as crystalline solids that have settled to the bottom of a liquid filled container. Some may float on the top of a liquid. Other homemade explosives may appear as non-crystalline solids. Residues of explosives may be left in mixing or storage containers; these can be extremely hazardous.

Colour and smell are not good indicators of the presence of explosives, as they vary depending on several factors, including the types of starting materials and their purities.

FLOWCHART D. MATERIALS COMMONLY USED FOR THE SYNTHESIS OF HOMEMADE EXPLOSIVES



FLOWCHART E. MATERIALS COMMONLY USED FOR THE SYNTHESIS OF HOMEMADE EXPLOSIVES



2.2 Health and safety

It is important to look at the circumstances of a scene in their entirety. These types of scenes are not always clean and tidy; time should be taken to assess them carefully.

DO NOT HANDLE any items believed to be involved in the manufacture of homemade explosives; contact a specialist immediately.

2.3 General indicators of clandestine manufacture of explosive substances

The manufacture of homemade explosives does not require specialist scientific equipment. Suitable equipment may include but is not limited to:

- food mixers/processors
- coffee grinders and blenders
- beaker
- buckets and bowls
- saucepans

- conventional kitchen hob or electric hotplate
- cold water bath or ice bath

Specialist tools are not required. Many tools used in household DIY are suitable and may include but are not limited to:

- pliers
- screwdrivers
- soldering iron and solder
- hammers
- batteries
- light bulbs
- electrical cables
- circuit boards
- commercial electronic items, such as switches, timers and clocks
- homemade detonators
- modified mobile phones

2.4 Scene evaluation

If the manufacture of homemade explosives is suspected, procedures for handling hazardous materials must be initiated, and the risks and the scene must be re-evaluated. Consultation with the appropriate specialist in explosives ordnance disposal (EOD, Bomb disposal) must be part of this re-evaluation process.

In addition to the fire investigation, a separate scene investigation may be conducted to examine the manufacturing process for the homemade explosive. This will involve appropriate specialists, including explosive experts, safety officers, and decontamination and clean-up personnel.

An overall multi-agency strategy must be discussed and agreed prior to any activities commencing. The strategy should include both the investigation of the fire/explosion scene and the manufacturing process for homemade explosives. It should be borne in mind that further destruction may be required if the homemade explosive material needs to be made safe by EOD or bomb disposal specialists.

The strategy must include (but is not limited to):

- evacuation plan of the immediate area
- scene preservation, including restricting access to the scene, creating different safety zones within the scene, etc.
- health and safety including managing/mitigating the risks from the chemical and explosive hazards present (ECHA, 2024)
- identification of the homemade explosive manufacturing process involved where possible
- safe shut down of any chemical processes in operation
- prioritisation of the scene examination in order to maximise the recovery of relevant evidence for both the fire scene investigation and the investigation of the preparation of the homemade explosive material(s)

APPENDIX H – WILDFIRES

1. FIRE DANGER ASSESSMENT

The Fire Weather Index (FWI) is a meteorologically based system used to assess forest and vegetation fire danger. It provides an indication of both the likelihood of ignition and the potential for fire growth and spread under prevailing environmental conditions. FWI data can assist investigators in determining whether a fire was likely to have started naturally and in understanding the conditions that influenced its subsequent development.

2. REMOTE SENSING AND FIRE DETECTION

NASA's Fire Information for Resource Management System (FIRMS) is a valuable tool for wildfire investigations. FIRMS provides near real-time satellite-based fire detection and monitoring data that can assist in identifying fire locations, progression, and historical fire activity.

Useful resources include:

- [NASA | LANCE | FIRMS](#)
- [FIRMS | NASA Earth data](#)

Satellite imagery and thermal hotspot data may provide important information regarding fire origin, timing, and spread.

3. FACTORS INFLUENCING WILDFIRE IGNITION AND DEVELOPMENT

The significance of environmental factors, and the interactions between them, can vary throughout the year. For example, deep soil dryness and wind may strongly influence fire spread and spotting behaviour (the transport of firebrands, which are airborne pieces of burning material ahead of the fire), while vegetation dryness and fuel load are often critical factors affecting ignition potential.

Factors that may influence the initiation and development of wildfires include, but are not limited to (NWCG, 2005; Kendall, Galloway and Milligan, 2024; Naszarowski et al., 2024; NWCG, 2025):

- Vegetation:
 - dryness of vegetation
 - vegetation type
 - vegetation density, including the quantity and continuity of available fuel
 - degree of drying of fuels such as grass, heath, heather, scrub, and dune vegetation
 - orientation of vegetation, for example:
 - standing vegetation
 - lodged or fallen vegetation
 - wind-flattened vegetation
 - location of vegetation, including whether the fuel is:
 - on the ground surface
 - immediately below the surface within the litter layer
 - within peat, duff, or other subsurface organic material
 - deeper within the soil profile
- Topography:
 - slope, being the change in elevation over a given distance
 - aspect, being the direction a slope faces and its resulting exposure to solar radiation, which can influence moisture content and fuel drying

- Terrain Features:
 - vegetated and non-vegetated areas, including rocky outcrops, bare ground, and water bodies
 - natural or artificial barriers and confinement features, such as:
 - roads
 - tracks
 - rivers
 - streams
 - firebreaks
 - rock formations
- Weather Conditions:
 - wind speed and direction
 - relative humidity
 - ambient temperature
 - dew and moisture deposition
 - precipitation history
 - atmospheric stability

4. INTERACTION OF CONTRIBUTING FACTORS

- Wildfire risk is often significantly increased when multiple adverse factors occur simultaneously. For example, severe drying of both vegetation and deeper soil layers may create substantially greater ignition and propagation potential than either condition alone.
- The interaction between fuels, topography, terrain, and weather should therefore be evaluated collectively rather than in isolation.
- Computer-based fire modelling and simulation tools may assist investigators in:
 - assessing fire spread patterns
 - evaluating alternative hypotheses
 - estimating rates of fire growth
 - illustrating fire development and progression

5. DRYNESS AND FUEL MOISTURE INDICATORS

Wind can significantly influence both fuel drying and fire spread. Environmental dryness should therefore form an important part of any wildfire investigation. Common indicators include:

- FPMC (Fine Fuel Moisture Code), representing the moisture content of fine surface fuels and their ease of ignition.
- DMC (Duff Moisture Code), indicating the moisture content of loosely compacted, decomposing organic material above the mineral soil.
- DC (Drought Code), representing moisture conditions in deeper organic layers and long-term drought effects.
- BUI (Build-Up Index), indicating the amount of combustible fuel available for sustained burning.

These indices may provide valuable context when assessing ignition potential and fire behaviour.

6. INDICATORS OF FIRE SPREAD AND DIRECTION

The analysis of fire patterns can assist in identifying the fire's direction of travel and the probable area of origin. Common indicators include:

- V-shaped wildfire patterns, which may be visible from aerial imagery and are formed by the outward spread of the fire front from the point of origin

- relative degrees of burning and damage within vegetation and other fuel sources
- grass stem, shrub, and branch indicators showing directional burning effects
- firebrand deposition patterns
- crown and surface fire transition indicators

In many cases, the fire heel (the area opposite the main direction of spread) may contain the area of origin. However, investigators should exercise caution when interpreting wildfire patterns, as fire behaviour may be affected by:

- wind shifts
- changes in fuel type
- topographical influences
- suppression activities
- spot fires
- extended burning duration
- variations in weather conditions.

Consequently, fire patterns should be interpreted alongside other available evidence. Reliable information sources that may assist in identifying the area of origin include:

- early-stage video recordings
- official news footage
- drone imagery
- satellite imagery
- emergency service records
- witness accounts
- photographs taken before suppression activities altered the scene

7. COMMON CAUSES OF WILDFIRES

Common wildfire ignition sources include:

- natural causes, such as lightning
- unintentional human activities, including:
 - campfires
 - discarded smoking materials
 - garden or rubbish burning
 - fireworks
 - Children's play involving fire
- deliberate ignition (arson)
- utility-related causes, such as vegetation contacting damaged or defective electrical distribution infrastructure
- spontaneous heating and ignition, resulting from biological, chemical, or other self-heating processes within combustible materials

8. FURTHER LEARNING RESOURCES

Additional information regarding wildfire science, behaviour, and investigation may be obtained from:

- Leverhulme Centre for Wildfires, Environment and Society
<https://centreforwildfires.org/>
- Fire Safety Research Institute (FSRI) Training Academy
<https://training.fsri.org/course/112/ifsc-series-of-webinars-on-wildland-fires>

9. DOCUMENTATION

See [Appendix K](#) “Case Notes” for an example wildfire scene examination pro forma.

APPENDIX I – REPORTING OF RAPID INVESTIGATIONS

1. GENERAL PRINCIPLES

Forensic science best-practice manuals are typically developed using examples of incident types that are frequently encountered and that present similar challenges in crime scene management. Good practice may be derived from organisational procedures, established investigation protocols, and the operational experience of practitioners. Collectively, these sources provide a framework to support investigators in the effective examination of commonly encountered incident scenes.

2. INVESTIGATIONS CONDUCTED UNDER EXCEPTIONAL CONSTRAINTS

Investigators may encounter incidents that require departure from conventional approaches and adaptation of established best practices. Such circumstances may arise where a rapid and efficient investigative response is required under significant time, resource, environmental, or operational constraints. Examples include incidents associated with international conflict, national security concerns, personal safety risks, or unavoidable scene degradation or destruction.

In such situations, investigators shall apply agile and adaptive approaches while maintaining the integrity of the investigative process. This requirement is particularly relevant to first responders, whose actions may significantly influence subsequent scene examinations and evidence recovery. Regardless of the complexity, uniqueness, or constraints associated with an incident, all investigative activities shall be conducted in a manner that supports the requirements of the judicial process.

3. ADAPTIVE INVESTIGATION APPROACHES

When responding to complex, unusual, or constrained incidents, investigators should identify the investigative domain(s) affected by the circumstances and adapt their strategies accordingly. Flexible and proportionate decision-making can support the efficient management of challenging investigations while maintaining the reliability, quality, and evidential value of the outcomes.

The objective should be to achieve investigative effectiveness through adaptation rather than through strict adherence to processes that may not be practicable under the circumstances. Additional guidance on strategic decision-making is provided in [Appendix B](#).

4. SPECIALIST INVOLVEMENT

Complex, unusual, or constrained incidents frequently require the involvement of suitably qualified and competent specialists. Depending on the nature of the incident, specialist expertise may include, but is not limited to:

- biological examinations
- building construction
- civil defence operations
- civil engineering (e.g. roadways and infrastructure)
- economics and financial analysis
- electrical examinations
- environmental science
- examination of materials and products
- fire and explosives examinations
- fire safety assessments

- forensic medical examinations
- geology and geotechnical engineering
- military operations
- photo-technical examinations
- traceological examinations
- transportation vehicles and systems
- video and audio recording examinations
- weapons examinations

The scope and extent of specialist involvement should be determined through risk assessment, investigative objectives, and operational requirements.

5. REPORTING CONSIDERATIONS

Where circumstances prevent a complete examination of the scene, the production of a comprehensive examination report with definitive findings may not be achievable. In such cases, reporting should focus on:

- meeting the minimum reporting requirements agreed with the end user
- clearly documenting the scope and limitations of the examination
- identifying evidential information obtained and any associated uncertainties
- recording the rationale for decisions made during the investigation
- supporting transparency and accountability in the decision-making process

Structured decision-making approaches may assist in managing complexity and uncertainty. Examples include the Cynefin decision-making framework (Snowden and Rancati, 2021).

When conducting rapid investigations, investigators should prioritise:

- timeliness
- flexibility
- operational efficiency
- quality assurance

These objectives shall be achieved without compromising the integrity, reliability, or traceability of the investigation.

Digital methods of scene documentation may support the efficient capture and preservation of information. However, an agreed investigation strategy and appropriate peer review processes shall remain essential components of the overall investigative framework.

6. DOCUMENTATION AND RECORD KEEPING

General requirements relating to scene documentation, recording practices, and evidence management are provided in:

- [Section 5 - "Methods"](#)
- [Section 8 - "Handling Items"](#)
- [Appendix K: Case Notes](#)

Investigators shall ensure that all records generated during rapid investigations remain proportionate, accurate, traceable, and sufficiently detailed to support subsequent review and judicial scrutiny.

7. DIGITAL TOOLS AND INFORMATION MANAGEMENT

A range of digital platforms and applications may assist in the efficient collection, management, and sharing of evidential information. Such systems can enhance the speed and consistency of data capture while supporting effective decision-making.

Examples include:

- the Swedish adaptation of the Norwegian fire protection data platform (*STAT*), available at: <https://stat.kub-hembesok.se/>
- the Incident Recording System (IRS) and associated evaluation initiatives used within the United Kingdom Fire and Rescue Services, available at [IRS Pilot Evaluation Report](#).

Any digital tool adopted for investigative purposes should be assessed for suitability, information security, data integrity, and compliance with applicable legal and organisational requirements.

8. ORGANISATIONAL REQUIREMENTS

The successful implementation of rapid or agile reporting processes may depend on the availability of supporting organisational infrastructure. This may include:

- secure information technology systems
- workflow and case-management platforms
- information-sharing mechanisms
- inter-agency coordination arrangements
- appropriate governance and oversight structures

Such capabilities are particularly relevant within police services, forensic science providers, emergency response organisations, and other investigative agencies seeking to maximise the benefits of rapid investigation and reporting approaches.

APPENDIX J – DETERMINATION OF CAUSE OF IGNITION AND EXAMPLES OF COMMON CAUSES OF FIRE

In every fire investigation, regardless of how the origin or circumstances of the fire are ultimately classified (e.g. deliberate, accidental, negligent, natural, or undetermined), an interpretation of the fire damage shall be undertaken to determine the most probable cause of ignition.

For the purposes of fire investigation, **ignition** may be defined as the process by which a rapid exothermic reaction is initiated and sustained, resulting in combustion and the thermal decomposition of the material involved. This process generates temperatures significantly above ambient conditions and may lead to the development and propagation of fire.

The determination of the cause of ignition should be based upon the systematic evaluation of all available information, including scene observations, witness accounts, physical evidence, fire patterns, analytical results, and relevant environmental or operational factors. Investigators should consider and, where appropriate, eliminate alternative hypotheses before reaching a conclusion regarding the cause of ignition.

Potential causes of ignition with examples of common causes of fire include, but are not limited to:

Auto-ignition	A substance spontaneously ignites in normal atmosphere without an external source of ignition: • biological self-heating (e.g. hay) • chemical self-heating (e.g. pyrophoric substances) • oxidation of combustible materials (e.g. rags contaminated with linseed oil)
Electrical	Heat generated from electrical energy, electrical faults, or electrically powered equipment provides an ignition source capable of initiating combustion in nearby combustible materials: • electrical equipment and appliances (e.g. short circuits, poor connections, overloaded circuits or insulation failure, defective components, or equipment malfunction) • lithium-ion battery systems (e.g. overheating, internal short circuits, mechanical damage, overcharging, or thermal runaway) • lighting equipment (e.g. overheated luminaires, halogen lamps, or faulty fittings) • heating equipment and electrical heaters (e.g. overheating, malfunction, inadequate clearance from combustibles, or misuse) • electrical distribution equipment (e.g. switchgear, circuit breakers, transformers, distribution boards, and power supplies) • portable electrical devices and charging equipment (e.g. chargers, extension leads, power adapters, power banks, and consumer electronics)
Embers	Ember are glowing fragments of combustible material that can retain and radiate substantial amounts of heat in the absence of a visible flame. Such materials may remain capable of igniting susceptible fuels long after the original fire or heat source has diminished. Fire spread caused by embers is particularly significant where combustible materials are exposed to prolonged radiant heating or direct contact with glowing particles.: • ashes and cinders (e.g. improperly discarded ashes from fireplaces, stoves, or wood-burning appliances) • airborne sparks and embers (e.g. from bonfires, wildfires, barbecues, incinerators, or hot-working activities) • glowing fire debris • live charcoal of briquettes (e.g. from a barbecues, grills, or cooking fires) • smoking materials (e.g. lit cigarettes, cigars, pipe tobacco, and associated smoking products) (Holleyhead, 1999; Ohlemiller, 1985) • lit joss-sticks, incense sticks and similar smouldering products • hot residues from solid-fuel appliances (e.g. wood, or coal)

Explosion	Explosions can create ignition sources directly through thermal effects or indirectly through the projection of hot gases, flames, molten materials, or incandescent particles. In some incidents, the explosion itself may initiate a fire, while in others it may occur as a consequence of an existing fire: • natural explosions (e.g. volcanic eruptions, geothermal events, or other naturally occurring energetic phenomena) • chemical explosions (e.g. high explosives, low explosives, combustible gas-air mixtures, volatile vapour-air mixtures, dust explosions, fireworks, and pyrotechnic compositions) • electrical explosions (e.g. high-energy electrical arc events, arc flashes, arc blasts, or electrical equipment failures resulting in the rapid vaporisation of metals and insulation materials) • mechanical and vapour explosions (e.g. BLEVEs, pressure vessel failures, compressed gas cylinder ruptures, and steam explosions)
Friction	Friction is the force that resists the relative motion of solid surfaces, fluid layers, or material elements moving against one another. The conversion of mechanical energy into heat through friction can generate temperatures sufficient to ignite combustible materials when heat generation exceeds heat dissipation. Examples include: • faulty or seized wheel bearings resulting in excessive heat generation • overheated braking systems caused by mechanical defects, dragging brakes, or prolonged braking • misaligned, damaged, or inadequately lubricated machinery components • friction between moving mechanical parts (e.g. shafts, gears, couplings, and bearings) • grinding, cutting, or abrasive processes that generate hot particles or sparks • metal-to-metal contact caused by wear, malfunction, or component failure • transportation-related mechanical failures involving vehicles, rail systems, or industrial equipment
Natural phenomenon	A natural phenomenon is an observable event or process that occurs without direct human intervention. Certain natural phenomena can generate sufficient heat or energy to initiate combustion and may therefore constitute a fire cause under specific circumstances. Examples include: • biological processes (e.g. fermentation or microbial activity generating heat within organic materials, leading to self-heating and potentially ignition) • chemical processes (e.g. spontaneous heating arising from oxidation reactions, including the self-heating of combustible materials) • geological phenomena (e.g. volcanic activities) • meteorological phenomena (e.g. lightning strikes, which may directly ignite combustible materials or damage electrical systems) • solar radiation (e.g. concentration of solar energy through reflective or focusing surfaces)
Open flame	An open flame can come from: • cigarette lighters • matches • candles • torches and blowtorches • open fires (e.g. fireplaces, fire pits, wood-burning stoves, burners, and campfires) • gas-fired cooking appliances (e.g. lit gas hobs, ovens, and grills) • portable fuel burning appliances (e.g. camping stoves and lanterns)

The investigator shall evaluate each potential ignition source within the context of the fire scene, the available fuel package, and the environmental conditions present at the time of the incident. Conclusions regarding the cause of ignition should be supported by the available evidence and documented in a transparent and scientifically defensible manner. Where the available evidence is insufficient to support a definitive conclusion, the limitations of the investigation and the basis for any opinion expressed shall be clearly stated.

APPENDIX K – CASE NOTES

Case notes may take many different formats. It is important that, whichever format(s) one chooses to use, the records are as comprehensive as possible such that a peer review, in the absence of the original scene, may be conducted as transparently and objectively as possible. A pro forma is a useful tool to ensure that an adequate level of information is captured. The following sections provide two such examples.

1. Example of a general fire investigation pro forma

Case number	
Requester Phone number	
Crime scene address Date and time	
Weather, wind and temp.	
Date and time for investigation	
Caseworker Co-examiner(s)	
External assistance	

Tactical information		
Health and safety		
Type of building		
☐ Villa/townhouse ☐ Farmhouse/country house	☐ Apartment building ☐ Cottage/lodge	☐ Business ☐ Other:
Construction		
Visual inspection		
Limitations and further investigation		
☐ Hallway/entrance/stairwell ☐ Kitchen ☐ Livingroom ☐ Bedroom ☐ Room(s)	☐ Toilet/bathroom ☐ Attic ☐ Cellar ☐ Laundry room ☐ Shed	☐ Outdoor ☐ Transport vehicles ☐ Industry ☐ Utility/boiler room ☐ Other

Investigation strategy			
INITIALLY	THEREAFTER	<u>FINALLY</u>	
Special equipment			
☐ Arson dog	☐ Special lights	☐	☐
Documentation			
☐ 360°	☐ Photo	☐ Drone	☐
Perimeter protection (doors, windows, locks)			
Traces			
☐ Shoe/footprint ☐ DNA/blood/fingerprint ☐ Internet of things (IoT)		☐ Marks ☐ Tire tracks ☐ Flammable liquids	
Secured samples (if many, please refer to a separate list)			

Area / point of origin (hypotheses – at least two)			
Locality			
☐ Hallway/entrance/stairwell ☐ Kitchen ☐ Living room ☐ Bedroom ☐ Room(s) ☐ Toilet/bathroom	☐ Attic ☐ Cellar ☐ Shed ☐ Outdoors ☐ Transport vehicles ☐ Industry	☐ ☐ ☐ ☐ ☐ ☐	
Furniture and storage			
☐ Furniture (chair, bed etc). ☐ Building structures ☐ Clothing ☐ Other home furnishings	☐ Electronic item ☐ Means of transport ☐ Barbecue/campfire	☐ Waste storage ☐ Other ☐ Inconclusive ☐	
Direction in location (if possible)			
☐ N	☐ S	☐ E	☐ W
☐ NW	☐ NE	☐ SW	☐ SE

Testing of hypotheses regarding the area/point of origin**Cause of fire**

(hypotheses – at least two or more)

☐ ...Electric heat conduction / convection:

- Electrical equipment and appliances (e.g. poor connections, overloading, or insulation failures on wires)
- Lighting equipment and heaters (e.g. overheated)

☐ ...Ember:

- Ash (e.g. from a conventional fireplace)
- Sparks (e.g., airborne embers from a campfire)
- Glowing fire residues/coals (from e.g. a barbecue)
- Lit cigarette
- Fireworks (also see open flame)

☐ ...Friction

- The force resisting (= friction) the relative movement of solid surfaces, liquid layers and material elements, sliding against each other (e.g. defective wheel bearings and brakes).

☐ ...Explosion

- Natural
- Chemical (e.g. explosives, gases)
- Electrical and magnetic (e.g. high-energy electric arc which quickly evaporates metal and insulating material)
- Mechanical and steam (e.g. BLEVE)

☐ ...Natural phenomenon

- Geological
- Meteorological (e.g. lightning)

☐ ...Open flame

- A lit lighter/matches
- A lit candle
- Fireworks (also see ember)

☐ ...Self-Ignition:

- Biological (e.g. hay)
- Chemical (e.g. pyrophoric substances)

☐ ...Other:**Testing of hypotheses regarding the cause of fire**

Conclusion	Hypothesis
The technical investigation shows that the source of the fire...	
The technical investigation strongly suggests that the source of the fire...	
The technical investigation indicates to some extent that the source of the fire/fire is	
No conclusion is possible because ...	
The technical investigation indicates to some extent contradicts the notion that the source of the fire...	
The technical investigation strongly indicates that the source of the fire...	
The technical investigation shows that the source of the fire...	

Plots / Sketches

(for example, BLUE=electrical, RED= fire damage, GREEN=excluded/no damage, BLACK=walls, openings, furniture etc)

2. EXAMPLE OF A WILDFIRE FIRE INVESTIGATION PRO FORMA

Case number			
Description of area and buildings:			
Fire damage:			
☐ less than 1 football pitch total 7000 m ²		☐ No, more m ²	
Security			
☐ Open	☐ Cordon off	☐ Closed and locked gate	
☐ Other			
Factors regarding fire spread			
Type of fire: ☐ Open area (field/heath/dune) ☐ Enclosed area (Tree- or bush tops/Forest) ☐ Non-visible area (bog/subsoil etc.)		Factors: ☐ Wind (speed) m/s ☐ Terrain (ascending/descending) ☐ Influenced by the sun ☐ Not affected by the sun	
Area/point of origin:			
People in the area during the fire			
☐ Yes	☐ No	☐ Unclear	Comment:
Cause of fire and fire course			
Heat source/ignition source:			
Ignited materials:			
Ignition factors (prerequisites for ignition/fire hazard index):			
If equipment is involved (type/model/serial number):			
Comment:			

APPENDIX L – EDUCATION AND TRAINING

1. INTRODUCTION

FIs have a range of experience, expertise and competence. Each FI should aim to be initially deemed trained and competent by an organisation or by completing a reputable course. During their career, it is incumbent on the FI to continuously improve their knowledge and understanding of the field, and to be able to evidence this growth.

FIs are encouraged to share their learning and experiences with other practitioners and to have their work robustly reviewed. They are encouraged to become members of recognised fire investigation associations. Furthermore, FIs should build their knowledge and experience as much as practicable using ground truth data. Where this data already exists, it does not need to be repeated but the FI should be aware of the conditions used.

All training, whether initial or on-going, should be documented. This documentation should include the training's format, duration and date completed. This evidence may be requested by court when evidence or experience is challenged and is therefore considered important.

2. REFERENCE KEY DOCUMENTS

Over and above the in-house documents for fire investigation, individual countries may have national guidance documents specific to the profession. Where these exist, the FIs must be aware of them and their contents. Where a country does not have such guidance documents, the following are a few examples that may be of use:

- Fire Investigation Code of Practice (CoP) for Investigators of Fires and Explosions for the Justice Systems in the UK
- Royal Society/Royal Society of Edinburgh Judicial Primer on fire investigation
- NFPA921 Guide for fire and explosion investigations

Additionally, there are other relevant documents but may or may not directly relate to fire investigation, for example:

- ILAC G19
- ISO/IEC 17025
- ISO/IEC 17020
- ISO 21043
- ENFSI BPM for multi-disciplinary examinations

Where the FI considers guidance information to be irrelevant or if they disagree with the information, they must be able to justify and defend their view scientifically to their national judicial authorities.

3. PRE-TRAINING LEARNING AND READING

Fire investigation is a practical exercise built on knowledge, experience and expertise. The FI must be able to relate knowledge from scientific papers and documents, training videos, and experiments to their investigations.

Whenever training is underway, pre-training materials should be identified for the FI to prepare and optimise the benefits of the training.

This pre-training material should be available, documented and completed before the training commences. Pre-training materials may include health and safety documentation, counter-contamination procedures, etc., which accompany fire investigations.

4. SCOPE

The purpose of the training should be clearly defined before being undertaken. The scope will cover the period of the training, who the training is for, who will deliver the training, what format it will take (in-person, online or hybrid), and the purpose and expected outcomes of the training.

Training should include demonstration by the trainer as well as supported learning.

5. LEARNING OBJECTIVES/OUTCOMES

Documentation of the learning objectives/outcomes helps both the trainer and the trainee to understand the curriculum and process of the training. The learning objectives/outcomes should be clearly defined with consideration given to theoretical educational models, such as Bloom's taxonomy (1956). Frameworks such as these allow for different levels to be applied to the same training (for example, memorisation versus critical evaluation and application).

Learning objectives need to be documented before training is undertaken with clear timelines and measurable outcomes. These objectives should clearly state the level of knowledge, comprehension and competence required, as well as how the training will achieve it.

Knowledge and competence should be measured at multiple points throughout the training: to ensure the pre-read and ongoing training materials have been understood and that, during the course of the training, the trainees continue to achieve the expected outcomes.

A documented process should guide trainees and trainers in addressing cases where a trainee has not achieved the expected outcomes and in supporting the trainee to close any knowledge or competence gaps.

6. IDENTIFYING TRAINING MATERIALS AND USE OF GROUND TRUTH MATERIALS FOR TRAINING

Fire investigation is a practical vocation, and while reading is essential to the professional development of the FI, training must, at some point, include practical exercise. This may not be the full fire investigation, but it could target a specific competence of fire investigation. For example, the student can read and remember how to carry out a stratigraphic excavation, but without cementing this knowledge with a practical example, may struggle when faced with the challenges of excavation at a scene. This could be addressed by the trainee practicing in a mock-up fire-damaged area with fire debris, or at a live scene, under the supervision of the trainer.

A ground-truth fire is one in which the ignition source, fuel, and point of origin are known. Ground truth examples are generally acknowledged as challenging to create and replicate. The acquisition of any ground truth data should be suitably documented.

While some trainers and trainees may have access to fire scene simulation facilities, live or digital, this is not the norm and should not be assumed so. Smaller test burns can also be used for training purposes where suitable.

Where full-scale test burns are available, every endeavour should be made to record them for future use. Recording methods can take different formats, including videography, virtual reality reconstructions (Yu *et al.*, 2023) of a real fire scene, and 360° imaging.

Test burns may be instigated for the purpose of testing a set of hypotheses for a live case investigation. Under such circumstances, the opportunity may also be used for training purposes. This could be to demonstrate burn patterns or other fire investigation related phenomena. The aim of the exercise for the trainee should be clearly defined in these

circumstances before the test burn takes place. Care should be taken when using videos of test burns for training, and only those from reputable or known sources should be used.

7. REVIEW AT MIDPOINT OR MILESTONES OF TRAINING

It is advisable for any training programme to have a clear midpoint and/or milestones for both the trainer and the trainee. This will allow the trainer and trainees to review progress and address any knowledge and competence gaps. Any identified issues should be addressed before progressing with the training.

Any review discussions and decisions at the mid-point and milestones should be documented.

8. MAINTENANCE OF COMPETENCE DEFINED

It is important to identify what is required for the FI to maintain their competence after training. This is likely to include investigating a number and variety of scenes that are peer-reviewed, continual professional development activities, and competency monitoring. The latter may involve on-site peer observations at specified periods of time (e.g. the FI may have to be observed by a peer at a live scene investigation every few years depending on their organisation's competence policy). The requirements for maintaining competence should be clearly stated in an appropriate training manual.

Accurate virtual reality (VR) representations of real fire scenes can also be used to test fire investigation competency for some tasks, e.g. identifying fire patterns, completing scene documentation, identifying potential areas of origin and potential ignition sources.

The FI should regularly review or consult new scientific literature to expand their knowledge and expertise. Where possible, organisations should invest in proven emerging technologies that may assist their FIs in performing their role.

9. ASSESSMENT

Before the training is considered completed and the FI is deemed competent, they should undergo an assessment or a series of assessments. An assessment may take several forms, such as demonstrating a set of skills in an activity, practical examinations, written tests, or an interview. Irrespective of format, there must be a set of clearly defined assessment criteria.

Fire investigation is multifaceted, therefore it may be practical to break down or group together some of the requisite competences and assess them separately or jointly as an organisation sees fit.

Once the trainee has been deemed competent in fire investigation, or an area of it, there should be a documented record of this from their organisation.

All training documentation should be retained and updated as required by national guidelines and organisational policies.

10. FEEDBACK FROM TRAINEES

After the training is completed, the trainers should seek feedback from the trainees to assess the effectiveness of their training.

It is important that the trainer also reviews the training from their own perspective and accommodates any changes that would improve the training going forward in a new version of the training documentation.

11. REVIEW OF TRAINING DOCUMENTATION

Irrespective of how frequently the training materials are used, there should be a stated review period for all documentation and materials.

12. MAINTAINING COMPETENCE AND CONTINUING PROFESSIONAL DEVELOPMENT

For fire investigation professionals, maintaining competence requires a commitment to keeping knowledge, technical skills, and investigative practices up to date with current legislation, standards, scientific developments, and industry best practice. Fire investigators must be able to apply sound investigative methodology, professional judgement, and critical thinking when determining fire origin and cause.

Competence is maintained through regular assessment of individual capabilities, participation in practical investigations, peer review, and engagement with lessons learned from casework. Investigators should also remain familiar with emerging fire trends, new technologies, and developments in fire science that may influence investigative outcomes. Interpol triannual reviews of publications in this scientific discipline (e.g. Evans, 2023) are a good source of information.

Continuing Professional Development (CPD) is essential to ensuring that fire investigators maintain and enhance their professional competence throughout their careers. CPD activities may include formal training courses, professional qualifications, attendance at conferences and seminars, participation in technical working groups, research, and self-directed study of relevant guidance and scientific literature.

Investigators should maintain accurate records of their development activities and periodically review their learning needs against the requirements of their role and professional standards. By actively engaging in CPD, fire investigation professionals strengthen the quality, credibility, and reliability of their findings while supporting public safety, the interests of justice, and confidence in the fire investigation profession.

APPENDIX M – LEVERAGING EMERGING OR NEW TECHNOLOGIES AND ANALYTICAL TECHNIQUES

1. GENERAL PRINCIPLES

Any emerging technology or analytical technique intended for use in forensic investigations shall, prior to implementation, be demonstrated to be scientifically reliable, validated for its intended purpose, and capable of producing results that are interpretable within the relevant legal framework(s). The introduction of new technologies or methods shall not compromise the integrity of the investigation, evidential materials, associated data, or the continuity of evidence.

Investigators should ensure that the limitations, uncertainties, and evidential value of any new technology or analytical approach are understood and adequately documented before its application in casework.

2. INTERNET OF THINGS (IOT) DEVICES

The increasing use of IoT devices, commonly referred to as connected smart devices, presents new opportunities for the acquisition of investigative information (Grispos, Studiawan and Alrabaee, 2024; Servida *et al.*, 2023). These devices are typically equipped with sensors capable of monitoring environmental conditions, human activity, equipment status, and system performance.

In fire investigations, IoT devices may provide valuable information relating to conditions before, during, and after an incident. Relevant data may be recorded not only on the device itself but also on associated smartphones, local networks, third-party applications, or remote cloud-based servers. Consequently, the potential scope of the investigation may extend beyond the physical fire scene.

Examples of relevant IoT devices include:

- smart smoke and heat detectors
- smart thermostats and environmental sensors
- home automation systems
- security and alarm systems
- smart appliances
- smart energy monitoring systems
- voice-controlled digital assistants
- connected surveillance cameras
- wearable devices

3. INVESTIGATIVE OPPORTUNITIES PROVIDED BY IOT SYSTEMS

A significant advantage of IoT technology is the ability of devices to communicate and exchange information across interconnected networks. As a result, multiple devices may collectively record information associated with an incident.

The analysis of IoT systems may assist investigators by:

- establishing timelines of events before, during, and after a fire
- identifying changes in environmental conditions such as temperature, smoke, humidity, or power usage
- recording user interactions with appliances or systems
- providing evidence of occupancy or activity within a property
- corroborating witness accounts or other evidential findings
- supporting the reconstruction of incident chronology

Such information may provide valuable contextual intelligence and, in some circumstances, evidential material relevant to determining the cause and development of a fire.

4. VEHICLE DATA AND CONNECTED TRANSPORT SYSTEMS

Modern vehicles incorporate extensive electronic systems, including numerous electronic control units (ECUs), advanced driver-assistance systems (ADAS), infotainment systems, telematics platforms, and event data recorders (EDRs). These systems may retain information relevant to both fire and collision investigations.

Data potentially available from modern vehicles may include:

- GPS location and journey history
- vehicle speed and operating parameters
- braking, steering, and acceleration data
- airbag deployment information
- event data recorder (EDR) information
- connected device histories
- call and communication logs
- vehicle diagnostic information
- camera recordings from integrated systems
- data from telematics service providers

Such information may assist in establishing the location, condition, usage, and operational status of a vehicle before an incident.

5. POTENTIAL BENEFITS FOR FIRE INVESTIGATION

Digital devices and connected systems may provide significant investigative opportunities, including:

- supporting the determination of fire origin and cause
- assisting in the reconstruction of incident chronology
- identifying potential ignition sources or precursor events
- providing information that may survive when physical evidence has been damaged or destroyed by fire
- identifying additional sources of evidence located remotely
- supporting intelligence-led investigative strategies

The distributed nature of many digital systems means that potentially relevant information may remain available even where device hardware has been damaged during the fire.

6. LIMITATIONS AND CHALLENGES

Although IoT devices and connected systems may provide useful investigative information, the acquisition, preservation, and interpretation of digital evidence can present significant challenges.

Investigators should consider:

- data ownership and privacy restrictions
- legal authority required for data access
- data retention policies of service providers
- variability in data quality and completeness
- proprietary data formats
- data authentication and verification requirements
- continuity and chain-of-custody considerations
- the ability to demonstrate evidential reliability in court.

Commercial service providers may restrict access to data or may provide information that lacks sufficient technical detail to address specific investigative or evidential questions. Consequently, information obtained from such sources should be evaluated critically and corroborated where possible.

7. DIGITAL VEHICLE FORENSICS

Vehicle manufacturers increasingly utilise connected sensors and monitoring systems to enhance vehicle safety and performance. These systems may include:

- forward-facing cameras
- rear-view cameras
- side-view cameras
- driver monitoring systems
- collision-avoidance sensors
- radar and lidar systems
- parking-assistance systems
- telematics-based monitoring platforms

Where vehicle-related evidence is relevant to the investigation, consideration should be given to the preservation and examination of available digital data.

8. SPECIALIST SUPPORT

The identification, recovery, preservation, and interpretation of digital evidence frequently require specialist knowledge and tools. Investigators should consult appropriately qualified specialists whenever digital devices, connected systems, cloud-based services, or vehicle data may provide information relevant to the investigation.

Consideration should be given to consulting specialists in:

- digital forensics
- network and cloud-based investigations
- IoT device analysis
- mobile device forensics
- vehicle and telematics forensics
- data analytics

The use of specialist expertise can assist in ensuring that digital evidence is acquired, interpreted, and reported in a scientifically robust and legally defensible manner.

APPENDIX N - GLOSSARY OF TERMS

Accelerant	The flammable material that is used in an arson to accelerate the combustion process and thus the development of a fire. An accelerant can be a solid (i.e. paper, PUR), liquid (i.e. petrol) or gas (i.e. propane).
Arc	An arc is created when the electrical current jumps the gap between two conductive materials (BS 7671). Neither BS 7671 nor the IEEE 346 (standard definitions) provide a specific, standalone definition of <i>arc</i> as a technical term. For the purpose of this BPM, the definition of an arc is: A high temperature/energy electrical discharge across a space between two conductive points, e.g. a gap between two ends of a broken energised conductor, or through a medium, e.g. carbonised insulation through thermal breakdown (i.e. arc tracking, also known as carbon tracking).
Arc-fault circuit interrupter (AFCI)	A device that detects unintended arcing at electrical loads or within circuits.
Arc mapping	The mapping and systematic analysis of locations of electrical arcs from circuits that have been involved in a fire in order to assess and evaluate its origin and progression.
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: • Biological (e.g. hay) • Chemical (e.g. pyrophoric substances)
Auto ignition temperature	The lowest temperature at which a combustible material ignites in air, without an external ignition source, such as spark or flame.
BLEVE:	Acronym for “Boiling Liquid Expanding Vapour Explosion”, explosion of containers filled with liquids after overheating.
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.
Combustible liquid	NFPA (2024b): A liquid with a closed-cup flash point of $\geq 37.8^{\circ}\text{C}$ (100°F).
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. ISO 8421-1:1987: Exothermic reaction of a combustible substance with an oxidiser, usually accompanied by flames, and/or glowing and/or emission of smoke.
Complete combustion	All combustible material is burnt away and consumed in the combustion process. This includes inorganic materials that are flammable and involved in the fire.
Condensation	Process by which a substance undergoes transition 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 (Fournier, 2016).
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. ISO 13943:2023: Combustion wave propagating at subsonic velocity. If within a gaseous medium, deflagration is the same as a <i>flame</i> .
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. Reaction is characterised by a shock wave propagating at a velocity greater than the local speed of sound in the unreacted material. ISO 13943:2023: Reaction characterised by a shock wave propagating at a velocity greater than the local speed of sound in the unreacted material.
Earth/ground fault current	A form of overcurrent stemming from a fault of negligible impedance between an energised conductor and an exposed conductive part of a load or a protective conductor.
Endothermic	A combustion process that cannot continue without the addition of heat.
Exothermic	A combustion process that releases heat and continues by itself independent of 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. ISO 13943:2023: <chemical> Abrupt expansion of gas which may result from a rapid oxidation or decomposition reaction, with or without an increase in temperature.
Explosive atmosphere:	Mixture with air (oxygen), under atmospheric conditions, of flammable substances in the form of gases, vapours, mists, aerosols or dusts in which, when ignition occurs, combustion spreads through the entire unburned fuel/air mixture. Atmospheric conditions: temperatures between -20 °C and 60 °C and pressures between 0,8 bar and 1,1 bar).
Explosive Limits:	The amount of vapour in air that forms an explosive mixture. 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. The lower and upper explosive limits are also referred to as LEL (Lower Explosive Limit) and UEL (Upper Explosive Limit). See also “flammability limits”.
Fault current	An overcurrent that stems from an electrical fault. A fault current can be either a short-circuit current (between phase and neutral) or an earth/ground fault current (between phase and earth/ground).
Fire	A self-sustaining combustion process during which heat, smoke, flames or embers are emitted.
Fire load	ISO 13943:2023: Quantity of heat which could be released by the complete combustion of all the combustible materials in a volume, including the facings of all bounding surfaces. Fire load may be based on effective heat of combustion, gross heat of combustion or net heat of combustion, as required by the specifier. Unit of measurement is kJ or MJ.

Fire resistance	ISO 13943:2023: The ability of a test specimen to withstand fire or give protection from it for a period of time. Typical criteria used to assess fire resistance in a standard fire test are fire integrity, fire stability and thermal insulation.
Flame	A luminous combustion zone that results from the reaction between gases and which creates heat. ISO 13943:2023: Rapid self-sustaining sub-sonic propagation of combustion in a gaseous medium, usually with emission of light.
Flame point	The lowest temperature at which a liquid can produce sufficient flammable vapour which when ignited by a flame or spark can support a continuous flame after the source of ignition is removed.
Flammable liquid	ECHA (2024): A liquid having a flash point of $<60^{\circ}\text{C}$. NFPA (2024a): A liquid with a closed-cup flash point of $<37.8^{\circ}\text{C}$ (100°F) and a maximum vapour pressure of 2068 mm Hg at 37.8°C (100°F). OSHA: Any liquid having a flash point $\leq 93^{\circ}\text{C}$ (199.4°F).
Flammability limits	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 the exposed surfaces of all flammable materials in the room reach their ignition temperatures and become involved in the fire. When this happens, the fire is described as fully developed.
Flashpoint	The lowest temperature at which a flammable liquid releases combustible vapour which when ignited by a flame or spark can support a momentary flame. The flame will extinguish upon removal of the source of ignition.
Fusing point (or melting point)	The temperature at which a material goes from solid form to the liquid/fluid phase.
Ground-fault circuit interrupter	A device that detects current imbalance between energised and non-energised conductors (e.g. when current returns via an unexpected conductor).
Heat conduction	Process by which heat flows through a solid material.
Heat flux	ISO 13943:2023: Amount of thermal energy emitted, transmitted or received per unit area and per unit of time. Unit of measurement is Wm^{-2} .
Heat release rate (HRR)	ISO 13943:2023: The rate of thermal energy production generated by <i>combustion</i> . Unit of measurement is W .
High resistance fault	An unintentional electrical path that permits enough current flow to generate heat, but not enough to trigger the current (circuit) protection device.
Ignitable liquid	NFPA (2024a): Any liquid or liquefied material that can fuel a fire, including flammable or combustible liquids, and any other substance that can be converted into a liquid and burned.
Ignition source	ISO 13943:2023: The source of energy that initiates combustion.
Ignition temperature	The temperature to which a material must be heated using a standard method for it to burst into flame in atmospheric air. ISO 8421-1:1987: Minimum temperature at which sustained combustion can be initiated under specified test conditions.
Ignition:	The process which initiates a self-propagating combustion. ISO 13943:2023: Initiation of combustion.
In situ	On site or on the premises.
Incendiary device	Devices that are used to facilitate ignition in a deliberately set fire. They can range from simple to sophisticated.

Incomplete combustion	A combustion process, stemming from a nonstoichiometric chemical reaction, in which not all flammable materials are consumed and burnt completely. Typical products of incomplete combustion include CO and soot (carbon).
Inert gas	A non-flammable gas. It may be used, for example, as a means of extinguishing fire. An inert gas works by “reducing the oxygen content in the protected room from the normal 20.9% to around 11.2% and thus can extinguish most types of fire. Inert gas is used in automatic extinguishing systems and for protecting enclosed areas, such as computer rooms and ship tanks. It can also be used for welding, e.g. carbon dioxide (CO ₂) or argon.
Lower Explosive Limit (LEL):	Minimum concentration of a gas or vapour in air below which flame propagation does not occur in the presence of an ignition source (e.g. electric arc/spark, or flame).
Miniature circuit breaker (MCB) and Moulded case circuit breaker (MCCB)	Electromechanical devices that protect low-voltage circuits. They open an electrical circuit (trip) when an unusually high current flow is detected, i.e. overcurrent. Typically, MCBs are used for lower current ratings (up to 100 amps, e.g. domestic and small commercial applications) while MCCBs are used for higher current requirements (up to 2,500 amps, e.g. industrial applications and larger loads). Some MCCBs may offer additional protection features, e.g. earth/ground fault detection.
Non-Combustible	ISO 13943:2023: Not capable of undergoing combustion under specified conditions. In some regulations, a material is classified as being “non-combustible” even if it is capable of combustion, provided that its heat of combustion is less than a defined amount.
Optimal mixture	The proportion of each component in a mixture of flammable gas and air which gives the quickest and cleanest combustion. Also called stoichiometric mixture.
Overcurrent	An electrical current that exceeds the prescribed rating of an electrical conductor. An overcurrent can be due to either an overload or a fault current.
Overload	A form of overcurrent when the load(s) being carried by the circuit exceeds its rated capacity, i.e. when too much current is flowing through a circuit that it can safely handle.
Oxygen	An odourless, colourless gaseous element. It is non-flammable but fuels a fire. Atmospheric air contains approximately 21% O ₂ .
Physical Explosion (or Mechanical Explosion):	Sudden bursting of a container due to mechanical failure and/or overpressure.
Point of Origin	The place at which the fire started. If a specific point of origin cannot be identified, it is called the area of origin.
Pyrolysis	Chemical degradation of a material due to thermal stress.
Radiation	The transfer of heat by means of electromagnetic waves.
Residue current device (RCD or residue current circuit breaker (RCCD)	A device that detects a leakage current by sensing current imbalances between the supply and return conductors.
Residue current circuit breaker with overcurrent protection (RCBO)	A device that combines the functionalities of a MCB and RCD, therefore protects against overcurrent and current leakage.

Scene-log	Record of all attendees at the scene containing detailed information on times of entry and exit.
Short circuit or short circuit current	A form of overcurrent stemming from a fault of negligible impedance between energised conductors when the current flows through a shorter, unintended pathway.
Slow burning	When burning is at speeds of between 1 and 10 mm per second.
Smoke	Small solid particles suspended in buoyant hot gases from a fire; caused by combustion or pyrolysis. ISO 13943:2023: visible part of a fire effluent.
Smouldering	ISO 13943:2023: Combustion of a material without flame and with or without visible light.
Spark:	ISO 13943:2023: <electrotechnical> Luminous discharge resulting from the dielectric breakdown of a gas between two electrodes. ISO 13943:2023: <thermal> Incandescent particle.
STP:	Standard Temperature and Pressure also known as NTP (Normal Temperature and Pressure).
Stratigraphic excavation	Stratigraphy is a key concept to modern archaeological theory and practice. Modern excavation techniques (Perrin <i>et al.</i> , 2014) are based on stratigraphic principles as applied in fire investigations: Original horizontality Lateral continuity
Sublimation	Sublimation is a process by which a solid substance undergoes transition directly to its gaseous/vapour state without passing through its liquid state (e.g. dry ice). Not all materials sublime.
Surge protection device (SPD)	A circuit protection device that detects and protects against electrical power surges that are known as transient overvoltage.
Unconfined Vapour Cloud Explosion (UVCE):	Explosion by the ignition and subsequent burning of gas, vapour, mist and/or dust in an open, unconfined environment.
Under ventilation	Development of a fire where the supply of air is less than what the fire needs.
Upper Explosive Limit (UEL):	Maximum concentration of a gas or vapour in air above which flame propagation does not occur in the presence of an ignition source (e.g. electric arc/spark or flame).
Vapour	The gaseous state of a substance which, under normal pressure and temperature conditions, is usually a liquid.

APPENDIX O - ABBREVIATIONS

ABBREVIATION	MEANING
3-D	3- dimensional
ADAS	Advanced driver-assistance systems
AFCI	Arc-fault circuit interrupter
APAAN	Alpha-phenylacetoacetonitrile
BEV	Battery electric vehicle
BLEVE	Boiling liquid expanding vapour explosion
BMK	Benzyl methyl ketone
BMS	Battery management system
BPM	Best practice manual
BS	British standard
BUI	Build up index
CBRN	Chemical biological radiological nuclear
CCTV	Closed-circuit television
CE	Collaborative exercise
CFI	Certified fire investigator
CNG	Compressed natural gas
CPD	Continuing professional development
CSI	Crime scene investigator
CSM	Crime scene manager
DC	Drought code
DCS	Distributed control systems
DDT	Deflagration to detonation transition
DMC	Duff moisture code
DNA	Deoxyribonucleic acid
Duff	Decomposing organic material above the soil (not an acronym)
DVI	Disaster victim identification
DVSA	Driver and vehicle standards agency
e.g.	(Latin) <i>exempli gratia</i> , meaning “for example”
EC	European community
ECHA	European chemicals agency
ECU	Electronic control units
EDR	Event data recorder
EEC	European economic community
EN	European norm (standard)
ENFSI	European network of forensic science institutes
EOD	Explosives ordnance and disposal
<i>et al.</i>	And others
etc.	Etcetera
EU	European union
EV	Electric vehicle
EWG	Expert working group
°F	Degrees Fahrenheit
FEI	Fire and explosion investigation
FEIWG	Fire and explosion investigation working group
FFMC	Fine fuel moisture code
FFP3	Filtering face piece (level 3)
FI	Fire investigator
FIRMS	Fire information for resource management system
FPV-IR	First person view- infra-red
FR	First responder
FWI	Fire weather index
FWK	Framework

GFCI	Ground-fault circuit interrupter
Gov	Government
GPS	Global positioning system
GSR	Gunshot residue
H&S	Health and safety
HEV	Hybrid electric vehicle
HGV	Heavy goods vehicle
HMTD	Hexa-methylene tri-peroxide di-amine
HSE	Health and safety executive (UK)
HVAC (system)	Heating, ventilation and air-conditioning
i.e.	(Latin) <i>id est</i> , meaning "that is" or "in other words"
IEC	International electrotechnical commission
IED	Improvised explosive device
IEEE	Institute of electrical and electronics engineers
IID	Improvised incendiary device
ILAC	International laboratory accreditation cooperation
IoT	Internet of things
IR	Infra-red
IRS	Incident recording system (UK)
ISO	International organization for standardization
IT	Information technology
kJ	Kilojoule
LANCE	Land atmosphere near real-time capability for EOS (earth observing system)
LED	Light emitting diode
LEL	Lower explosive limit
LiDAR	Light Detection and Ranging
LPG	Liquified petroleum gas
MCB	Miniature circuit breaker
MCCB	Moulded case circuit breaker
MEK	Methyl, ethyl ketone
MEKP	Methyl, ethyl ketone peroxide
MJ	Megajoule
NASA	National aeronautics space administration
NFPA	National fire protection association (US)
NHTSA	National highway traffic safety administration (US)
NTP	Normal temperature and pressure
°C	Degrees Celsius
OSHA	Occupational safety and health administration (US)
P2P	Phenyl-2-propanone
PAH	Polycyclic aromatic hydrocarbons
pH	Potential (or power) of hydrogen
PPE	Personal protective equipment
PT	Proficiency test
PUR	Polyurethane
QCC	Quality and competence committee
QMS	Quality management system
RAW	An uncompressed file- not an acronym
RCBO	Residual current circuit breaker with overcurrent protection
RCCB	Residue current circuit breaker
RCD	Residue current device
RGB-D	Red, green, blue, depth
RPE	Respiratory protective equipment
SCADA	Supervisory control and data acquisition systems
SD (CARD)	Secure digital
SIO	Senior investigating officer

SPD	Surge protection device
STEP	Sequential timed event plot
STP	Standard temperature and pressure
TATP	Tri-acetyl tri-peroxide
TV	Television
UAS	Unmanned aerial systems
UEL	Upper explosive limit
UV	Ultra violet
UVCE	Unconfined vapour cloud explosion
VIN	Vehicle identification number
VOSA	Vehicle and operator services agency
VR	Virtual reality
Vs	Versus

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