TWGFEX Laboratory Explosion Group
Standards & Protocols Committee

Recommended Guidelines for Forensic Identification of Intact Explosives

---

1.1 Introduction:

The purpose of this document is to set forth guidelines for the forensic identification of intact (unconsumed) explosives. It is recognized that the correct characterization and/or identification of an explosive depends on the use of scientifically acceptable analytical methods and the expertise of the analyst. Unique requirements in different jurisdictions may dictate practices followed by a particular laboratory. This document does not discourage the use of any particular method within an analytical scheme and recommends the use of multiple techniques based on different principles and methodologies. Analytical chemistry is an advancing science and there are other analytical techniques which are not listed in the document but which may be employed in the identification of explosives. These may be new techniques or established techniques (i.e. NMR), which are not routinely used in forensic laboratories.

1.2 Categorizing Analytical Techniques:

For purposes of this document, techniques for the analysis of explosive samples may be broken down into four categories: (1) those that provide significant structural and/or elemental information, (2) those that provide limited structural or elemental information, (3) those that provide a high degree of selectivity, and (4) those that are useful but do not fall in either of the other categories. Table 1 lists examples of such techniques based on the 1999 TWGFEX survey of explosion debris analysts in the United States.

Table 1: Categories of Analytical Techniques

Categories 1 and 2	**Category 3**	**Category 4**
Infrared Spectroscopy (IR)	Gas Chromatography (GC)	Burn Test
Gas Chromatography/Mass Spectrometry (GC/MS)	Gas Chromatography Thermal Energy Analyzer (GC-TEA)	Flame Test
Energy Dispersive X-Ray Analyzer (EDX)	Liquid Chromatography (LC)	Spot Test
Raman Spectroscopy	Liquid Chromatography Thermal Energy Analyzer (LC-TEA)	Melting Point
X-Ray Diffraction (XRD)	Ion Chromatography (IC)	
Liquid Chromatography/ Mass Spectrometry (LC/MS)	Capillary Electrophoresis (CE)	

Categories 1 and 2	Category 3	Category 4
	Thin Layer Chromatography (TLC)	
	Ion Mobility Spectrometry (IMS)	
	Polarizing Light Microscopy (PLM)	
	Stereo Light Microscopy (SLM)	

1.3 Recommended Practices:

1.3.1 Good laboratory practices suggest that multiple techniques be employed in forensic explosive identification and that supporting analytical data be available for review. Examples of such data include printed chromatograms, photographs/photocopies of results, or detailed descriptions of morphological characteristics.

1.3.2 Examination of suspected explosives should start with macroscopical and microscopical observations and, when appropriate, a burn test. The usefulness of these initial tests assumes the examiner has a working knowledge of explosives. While the visual examination and burn test may be suggestive of an explosive, it is necessary to use additional analytical techniques to identify the explosive compound itself or its key constituents. The key constituents are highlighted in red (or shaded in B&W copies) for each applicable type of explosive on the chart in Appendix A.

1.3.3 In addition to the visual examination and burn test of the intact sample, individual component(s) (shaded or in red in Appendix A) of the explosive must be identified as follows:

1.3.3.1. A technique identified with a numeral 1 is sufficient for identification.
1.3.3.2. A technique identified with a numeral 2 requires one more supporting technique for identification.
1.3.3.3. A technique identified with a numeral 3 requires two more supporting techniques for identification.
1.3.3.4. A technique identified with a numeral 4 requires three more supporting techniques for identification.

1.3.4 Clarifications to 1.3.3

1.3.4.1 When identifying ions, two techniques per ion are required.

1.3.4.2 Some category 3 techniques lend themselves to being counted twice:

- Chromatographic techniques may be counted as two distinct Category 3 methodologies when different stationary and/or mobile phases are employed.
- PLM may be counted as two distinct Category 3 methodologies when 2 different identification tests are done, such as examination of the physical/optical properties plus a microcrystalline test

1.3.5 For an analytical technique to be considered of value, the test must be considered 'positive'. While 'negative' tests provide useful information for ruling out the presence of a particular family of explosives, these results have limited value toward establishing the identification of an explosive substance.

1.3.6 Forensic laboratories are encouraged to establish reference collections. The collections should contain explosives that the laboratory is likely to encounter. Digital images or photographs of a few examples of each explosive would be useful to assist examiners. Examples include:

1. Black Powder
2. Pyrodex®/ Triple 7®
3. Black Canyon®/Clean Shot®
4. Flash Powder/Pyrotechnic
5. Smokeless Powder (single-base & double-base)
6. Dynamite
7. Watergel/Slurry
8. Emulsion
9. ANFO
10. Binaries (e.g. Kinepak®)
11. Plastic Bonded Explosives
12. Single Component Explosive (e.g. TNT, PETN, RDX, HMX, EGDN, Tetryl, Azides)

1.4 Appendix A is a chart showing analytical techniques that may be used for identifying common, intact commercial explosives. This chart also shows the recommended constituents (in RED or shaded) that must be individually identified for multiple component explosives. The identification of these components forms the basis for identification of the explosive material.

1.5 Safety:

The laboratory is strongly encouraged to establish safety protocols for the safe execution of these procedures.

1.6 Summary:

It is understood that the forensic identification of an explosive may be accomplished by a variety of analytical techniques. These guidelines recommend that at least one Category 1 technique be utilized in performing forensic explosive identifications. The use of multiple techniques and methodologies that provide structural and/or elemental information about an explosive is strongly recommended. It should be recognized that these guidelines are minimum standards for the identification of explosives. Within these guidelines, it is at the discretion of the individual analyst to determine which combination of analytical techniques satisfies the requirements for the identification of an explosive.

These guidelines were formulated with the express intent of application to commercial explosives. Improvised explosives should be identified using similar principles.

APPENDIX A
Minimum Analysis Requirements for Identification of Intact Explosives

MATERIAL	GC/MS	LC/MS	IR	EDX	RAMAN	XRD	GC/TEA	GC	LC/TEA	LC	IC	CE	TLC	IMS	PLM	SLM	BURN	FLAME	SPOTS	MELTING POINT
Black Powder																3	4			
Potassium Nitrate			1	3	2	1					3	3			3			4	4	
Sulfur	1			1		1									3	3			4	
Carbon				2											3	3	4			
Pyrodex																3	4			
Potassium Nitrate			1	3	2	1					3	3			3			4	4	
Potassium Perchlorate			1	3	2	1					3	3			3			4	4	
Sodium Benzoate	2		1	3	2	1				3	3	3			3					
Dicyanodiamide	1		1							3	3	3			3					
Sulfur	1			1		1									3	3			4	
Carbon				2											3	3	4			
Triple 7																3	4			
Potassium Nitrate			1	3	2	1					3	3			3			4	4	
Potassium Perchlorate			1	3	2	1					3	3			3			4	4	
Sodium Benzoate	2		1	3	2	1				3	3	3			3					
Dicyanodiamide	1		1							3	3	3			3					
Absence of Sulfur																				
Carbon															3	3	4			
Black Canyon/Cleanshot																3	4			
Ascorbic Acid	1		1		2	1				3		3			3					
Potassium Nitrate			1	3	2	1					3	3			3			4	4	
Flash Powder																3	4			
Metal Fuel				1		1									3	3			4	
Oxidizer			1	3	2	1					3	3			3			4	4	
Fillers/Binders			2		2										3	3				
Smokeless Powder																3	4			
Nitrocellulose (SB)			1		2								3						4	
Nitroglycerin (DB)	1		1		2		3		3			3	3	3					4	
Dynamite																3				
Nitrate Esters (ID all Present)																				
Nitroglycerin	1		2		2		3		3			3	3	3					4	
EGDN	1		2		2		3		3			3	3	3					4	
Metriol trinitrate (MTN)	1		2		2		3		3			3	3						4	
DEGDN	1		2		2		3		3			3	3						4	
Ammonium/Sodium Nitrate			1	3	2	1					3	3			3				4	
Filler Material			2	3	2	2									3	3				
Other inorganic salts			2	3	2	1					3	3			3				4	
TNT	1	1	1		2	1	3					3	3	3	3				4	4
PETN	1	1	1		2	1	3		3			3	3	3	3				4	4
RDX	1	1	1		2	1	3		3			3	3	3	3				4	
HMX	1	1	1		2	1	3		3			3	3		3				4	
EGDN	1		2		2		3		3			3	3	3					4	
TATP	1		1		2	1									3		4		4	4
HMTD	1		1		2	1									3		4		4	4
TETRYL	2	1	1		2	1	3		3			3	3	3	3				4	4
WATER GELS/SLURRIES																3				
Inorganic Nitrate			1	3	2	1					3	3			3	3			4	4
Gelling Agent(polysaccharides)			1		2															
Sensitizers (ID all Present)																				
Microballoons			2	1											1	3				
Aluminum				1		1									3	3			4	
MMAN/EDDN			1		2		3		3		3	3	3							
EMULSIONS																3				
Inorganic Nitrate			1	3	2	1					3	3			3	3			4	4
Oil/Wax	1		1					1												
Emulsifiers	1		2		2															
Sensitizers (ID all Present)																				
Microballoons			2	1											1	3				
Aluminum				1		1									3	3			4	
ANFO																3				
Ammonium nitrate			1	3	2	1					3	3			3	3			4	4
Fuel Oil	1				2			1												
BINARIES(Kinepac,Thermex,etc)																3				
Ammonium nitrate			1	3	2	1					3	3			3	3			4	4
Nitromethane	1		1		2			3				3								
PLASTIC BONDED EXPLOSIVES																3				
Explosive (RDX, HMX, PETN)	1	1	1		2	1	3		3			3	3	3	3				4	
Dye	1		1		2					3		3	3							
Binder			1		2															
Plasticizer	1		1		2			3				3								
Oil	1							1												
DMNB (taggant)	1						3		3			3		3						
PRIMARY EXPLOSIVES																3	4			
Azides			1	3	2	1					3	3			3				4	
Styphnates			1	3	2	1						3			3				4	
Diazodinitrophenol (DDNP)	1		1		2	1		3				3			3				4	
Fulminates			1	3	2	1									3				4	