Marking, Rendering Inert, and Licensing of Explosive Materials: Interim Report

Committee on Marking, Rendering Inert, and Licensing of Explosive Materials, National Research Council

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Interim Report

Committee on Marking, Rendering Inert, and Licensing of Explosive Materials
Board on Chemical Sciences and Technology
Commission on Physical Sciences, Mathematics, and Applications
National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Board on Chemical Sciences and Technology
National Research Council
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Committee on Marking, Rendering Inert, and Licensing of Explosive Materials

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Project Staff

DOUGLAS J. RABER, Study Director and Director, Board on Chemical Sciences and Technology (BCST)
ROBERT SCHAFRIK, Director, National Materials Advisory Board (NMAB)
GREG EYRING, Consultant, NMAB
SANDRA HYLAND, Senior Program Officer, NMAB
RYANNE J. MAYERSAK, Research Assistant, BCST
TRACY D. WILSON, Senior Program Officer, BCST

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Staff

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Preface

The Committee on Marking, Rendering Inert, and Licensing of Explosive Materials (see Appendix A) was appointed by the National Research Council to address four basic areas: (a) the viability of adding tracer elements to explosives for the purpose of detection, (b) the viability of adding tracer elements to explosives for the purpose of identification, (c) the feasibility and practicability of rendering inert common chemicals used to manufacture explosive materials, and (d) the feasibility and practicability of imposing controls on certain precursor chemicals used to manufacture explosive materials. (See Appendix B for a detailed statement of task.) As part of these tasks, the committee is also considering risks to human life or safety, utility to law enforcement, effects on the quality and reliability of the explosive materials for their intended lawful use, potential effects on the environment, and the cost-effectiveness of these approaches.

The study focuses on issues in science and technology, with the goal being to frame the issues and furnish a report that provides a clear description of the technical options that exist. The committee's final report of the results of this study will provide advice to officials of the Bureau of Alcohol, Tobacco, and Firearms on which to base recommendations to Congress. It will also clearly set forth any opinions and findings obtained as a result of consultation with other federal, state, and local officials, regulated industry members, and fertilizer research centers. This interim report describes progress to date (March 1997) and summarizes recent workshop presentations concerning current developments and critical issues in “tagging” explosive materials for the purposes of detection or identification. The final report containing the committee's conclusions and recommendations will be published in February 1998.

In its initial meetings, the committee received a number of briefings (see Appendix C) and held subsequent deliberations. These presentations are summarized in this interim report. The reader is cautioned that the committee does not present any conclusions or recommendations in this report, as it believes it is premature to do so at this time.

This study is being conducted by the Board on Chemical Sciences and Technology with technical insights and assistance provided by the National Materials Advisory Board and its staff. The committee acknowledges this support. The committee is also grateful to the many individuals who provided technical information and insights during briefings at the committee's initial meetings. This information represents a sound foundation on which the committee can base its continuing work. The committee continues to solicit input from the scientific community and affected stakeholders on the issues delineated in the committee's charge and to consider other sources of information relevant to this study.

The chair is also particularly grateful to the members of this committee, who worked diligently and effectively on a demanding schedule to produce this interim report.

MARYE ANNE FOX, CHAIR

COMMITTEE ON MARKING, RENDERING INERT, AND LICENSING OF EXPLOSIVE MATERIALS

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Marking, Rendering Inert, and Licensing of Explosive Materials

INTRODUCTION

Following several major bombing incidents in the United States in the 1990s, most notably the New York World Trade Center and the Alfred P. Murrah Federal Building (Oklahoma City) bombings, considerable discussion at the federal level has focused on ways to reduce the threat of terrorism. In particular, there has been interest in the possibility of reducing the threat through some combination of decreasing the explosive potential of certain chemicals that might otherwise be used to manufacture explosives; introducing additives, called "taggants," into explosive materials to permit detection or tracing of the material; and imposing licensing or other controls on explosive materials or their chemical precursors. Explosives made from mixtures of ammonium nitrate and fuel oil (ANFO) were used in some of the most publicized bombing incidents. ANFO is the most widely used commercial explosive in the United States,[1] and any new legal or regulatory requirements could have a direct impact on a broad range of U.S. industries, particularly the chemical, fertilizer, and mining industries. Other industries and private-sector groups have taken strong positions with respect to various proposals in this controversial area (see the section below titled "Taggant Stakeholders").

The possible use of taggants was examined more than 15 years ago in a study by the Office of Technology Assessment.[2] That study considered taggants to be additives that could survive an explosion and be used to trace the origin of the materials or additives that would enhance the detectability of the explosives prior to an explosion. The former have been used overseas, particularly in Switzerland, for a number of years,[3] although a variety of new taggant approaches are being developed. Similarly, remarkable progress has been made in trace chemical analytical instrumentation that could be applied to detection of tagged or untagged explosives. However, questions persist about the efficacy, safety, and cost of using taggants. In addition, industry trade associations and private-sector groups have raised a variety of economic and legal questions that must be considered within the technical context of specific approaches to using taggants.

[1] See Hopler, Robert. 1997. "Today's Commercial Explosives Industry: Trends in Products and Operations." Washington, D.C.: Dyno Nobel Inc.
[2] Office of Technology Assessment. 1980. Taggants in Explosives. Washington, D.C.: Government Printing Office. April.
[3] Explosives Symposium, ATF, Fairfax Virginia, September 18–22, 1995.

Actions Leading to This Study

The language of Title VII of the Antiterrorism and Effective Death Penalty Act of 1996 ("Terrorism Prevention Act," see Appendix D) mandates (through the Treasury Department) a study of issues related to detection, tagging, rendering inert, and licensing of explosives. The Treasury Department's Bureau of Alcohol, Tobacco, and Firearms (ATF), which has regulatory responsibility for explosives, has in turn asked the National Research Council to assist in conducting this study,[4] whose progress to date is reported in this interim report. (The ATF has its own task force that is also examining many of the same issues of this study. The National Research Council has been tasked with providing a totally independent assessment.)

Statement of Task

Issues to be addressed in the committee's final report include:[5]

- the viability of adding tracer elements to explosives for the purpose of detection,
- the viability of adding tracer elements to explosives for the purpose of identification,
- the feasibility and practicability of rendering inert common chemicals used to manufacture explosive materials, and
- the feasibility and practicability of imposing controls on certain precursor chemicals used to manufacture explosive materials.

The study will include analyses that address risk to human life or safety, value to law enforcement officers, effect of taggants on the quality of the explosive materials for their intended lawful use, and effects on the environment. The analyses will include cost drivers, benefits, and potential drawbacks for various technical alternatives.

In order to make sound decisions, the Treasury Department and ATF would like a thorough description of what scientific and technological options exist, including a discussion of technologies that are available, under development, or needed, as well as their potential effects on industry, law enforcement, and consumers. It would also include the identification of technical and economic obstacles that exist and further research and development activities that may be needed. While this study has a science and technology focus, the committee's final report will reflect input from all stakeholders.

[4] In accordance with recent amendments to the language of the Terrorism Prevention Act (see Appendix D), the ATF has asked the National Research Council to form an independent panel to study the use of taggants with black and smokeless powder, which had previously been specifically excluded by legislative action. This panel will issue a separate report.

[5] See Appendix B for a more detailed description of the statement of task.

Scope of the Study

This study will focus on improvised and commercial explosives rather than military or plastic explosives that are the subject of Title VI of the Terrorism Prevention Act. Also, black and smokeless powder are excluded from the scope of this study.[6] This interim report does not include any of the committee's conclusions or recommendations, which will be presented in the final report to be published in February 1998.

Approach to Conducting the Study

The Committee on Marking, Rendering Inert, and Licensing of Explosive Materials was appointed by the National Research Council under the management of the Board on Chemical Sciences and Technology, in collaboration with the National Materials Advisory Board. Four panels, each comprising half of the membership of the full committee, were assigned to address each of the four major tasks (see above bulleted items) in parallel.

The full committee has held three meetings for information gathering purposes, focused primarily on the first two tasks of its charge: detection and identification of taggants. Taggant vendors, stakeholders, and outside experts were invited to brief the committee.

As the study continues, additional experts, including government and industry representatives as well as individuals from the various stakeholder organizations that are concerned with issues of the study, will be asked to meet with the committee. Technical briefings will also be solicited from representatives of international government and private-sector organizations with relevant expertise. Several committee or subcommittee meetings will involve site visits to allow the committee members to gather information about specific technological problems, manufacturing technologies, or proposed technical solutions to some of the issues being studied. One or more of the site visits may involve international travel so that committee members can evaluate strategies that have been adopted by other countries.

[6] As mentioned above, the ATF has requested that the National Research Council form a separate panel to study the feasibility and practicability of tagging smokeless and black powder for purposes of detection and identification.

BACKGROUND

Current Explosives Threat.

The most recently compiled bomb threat data from the Bureau of Alcohol, Tobacco, and Firearms[7] and Federal Bureau of Investigation (FBI)[8] is shown in Table 1. The data for property damage and injuries in 1993 was significantly affected by the bombing of the World Trade Center in New York; the 1995 data was affected by the bombing of the Alfred P. Murrah Federal Building in Oklahoma City. For example, the bombing of the World Trade Center in 1993 caused $510 million in damage and resulted in 1042 persons injured—a significant portion of the 1993 data.

The most common materials used as ingredients in destructive devices in 1994 were reportedly flammable liquids (29%); various chemicals (26%); black powder (16%); photoflash/fireworks powders (16%); smokeless powder (9%); military explosives other than C-4 and TNT (1%); and dynamite/water gels, matchheads, blasting agents (including ammonium nitrate fuel oil, (ANFO)), and other fillers (2%). Ammonium nitrate fuel oil (ANFO), although used in a few highly publicized bombings, is not a frequently used ingredient. Significant amounts of information are now available on the Internet, compounding the bombing threat.

TABLE 1 Historical Bomb Threat Data

Type of Incident	1990	1991	1992	1993	1994	1995
Bombings	931	1551	1911	1880	1916	1562
Attempted bombings	254	395	384	375	522	417
Incendiary bombings	267	423	582	538	545	406
Attempted incendiary bombings	130	130	112	187	180	192
TOTAL	1582	2499	2989	2980	3163	2577
Reported killed	27	29	26	49	31	193
Reported injured	222	230	349	1323	308	744
Reported property damage	$9.6M	$6.4M	$12.5M	$518.0M	$7.5M	$105.1M

SOURCE: FBI Explosives Unit, Bomb Data Center. 1997. “1995 Bombing Incidents,” General Information Bulletin 97-1.

[7] Department of the Treasury, Bureau of Alcohol, Tobacco and Firearms. 1995. Arson and Explosives: Incidents Report 1994. ATF P 3320.4. Washington, D.C.: Government Printing Office.

[8] FBI Explosives Unit, Bomb Data Center. 1997. “1995 Bombing Incidents,” General Information Bulletin 97-1.

TAGGANT TYPES AND PREVIOUS USES

Two different kinds of taggants are commonly discussed. Detection taggants are materials added to explosives that can be sensed (pre-blast) by an associated detection instrument. Identification taggants are additives designed to survive an explosive blast, to be recoverable at the bomb scene, and to provide pertinent information, such as last legal purchaser, to aid law enforcement personnel in identifying the perpetrator.

Detection Taggants

A number of technologies exist to detect *untagged* explosive materials, including dual-energy x-ray, x-ray computed tomography, thermal neutron activation, vapor/particle detection, and use of canines.[9] Detection taggant schemes may improve the specificity and efficiency of these detection technologies or make new methods possible.

Taggant options include addition of volatile chemicals, radioisotopes, or electromagnetic taggants. In countries ratifying the International Civil Aviation Organization's "Convention on the Marking of Plastic Explosives for the Purpose of Detection," plastic explosives are currently being tagged, or "marked," with one of four volatile chemicals. [10]

Identification Taggants

Identification taggants can encode information in a variety of ways and can be added at various points in the production and distribution process. Microscopic plastic particles are the most well known form of identification taggant. The color sequence of the colored layers that compose the particles is used for identification. Another approach uses polymeric microbeads of various sizes and colors. Other approaches use rare-earth elements in a synthetic matrix blended with fluorescent pigments and iron powder, isotopic methods, and immunoassay techniques.

[9] National Research Council. 1993. Detection of Explosives for Commercial Aviation Security. Washington, D.C.: National Academy Press.

[10] The United States has chosen to use 2,3-dimethyl-2,3-dinitrobutane (DMNB).

History of Taggant Research and Use

During 1977 to 1980, a pilot test was conducted for the ATF by the Aerospace Corporation. This feasibility demonstration program evaluated the addition of identification taggants manufactured by the 3M Corporation to 6.4 million pounds of packaged, cap-sensitive explosives manufactured by four companies (Atlas, DuPont, Hercules, and Independent). Taggant addition during manufacture, recordkeeping, and taggant recovery and analysis procedures were evaluated.[11]

In 1980, the Swiss government began requiring that all manufactured explosives contain identification taggants to aid in criminal investigations. Some success in resolving bombing cases has been reported,[12] although the usefulness of the Swiss experience is controversial, in part because of differences between the U.S. and Swiss explosives industries. [13]

Previous Evaluation of Taggants

In 1980, the Office of Technology Assessment (OTA) examined the use of identification taggants in commercial explosives.[14] While it concluded that taggants could be useful for law enforcement, OTA noted the need for further development and safety/compatibility evaluation testing.

COMMITTEE'S APPROACH TO EVALUATION OF TAGGANTS

Taggant Taxonomy

In an effort to categorize the many existing and proposed taggant concepts, the committee developed a draft taggant concepts taxonomy as shown in Box 1. Such a taxonomy should prove useful for stimulating thinking about new taggant approaches and for ensuring a complete consideration of taggant concepts. The reader is cautioned that this taxonomy is only a draft tool being used to stimulate committee thinking at this point.

[11] Aerospace Corporation. 1980. Identification Tagging Pilot Test for Packaged, Cap-Sensitive Explosives: Final Report. ATR-80(5860-03)-1ND. Washington, D.C.: Aerospace Corporation.

[12] Scharer, J. 1995. “Switzerland's Explosives Identification Program,” in Proceedings of the International Explosives Symposium. Fairfax, Va.: Government Printing Office.

[13] Ronay, C. 1997. Testimony to the Committee on Marking, Rendering Inert, and Licensing of Explosive Materials.

[14] Office of Technology Assessment. 1980. Taggants in Explosives. Washington, D.C.: Government Printing Office.

BOX 1 DRAFT TAGGANT CONCEPTS TAXONOMY

(A) Detection Taggants

1. Active-things that "tell you explosives are there"

a. Electronics-electromagnetic radiation (from RF to UV-visible)
b. Sound-also probably electronic, but different output
c. Radioisotope-emitting particles or gamma radiation
d. Volatile chemical-emitting detectable molecules
e. Other

2. Passive-things that respond to a query

a. Electromagnetic excitation or scattering of contrast additives
b. Particle excitation or scattering of contrast additives
c. Electronics
d. Sound

(B) Identification Taggants

1. Physical-macro level

a. Marking package (e.g., bar coding) or detonator cap (mainly for unexploded material)
b. Coded particle (e.g., colored plastic "bar code," ceramic particle containing fluorescent rare-earth compounds, ceramic particle containing magnetic rare-earth compounds)

2. Chemical/Molecular-micro level

a. Coded molecule (e.g., combinatorial variation of short-chain polymer or chlorinated aromatic compounds, isotopic mixtures of readily detected radioactive or non-radioactive elements)
b. Coded mixture of chemicals (e.g., "digitized" mixture of fluorescent chemicals, etc., concentration code determined by chemical assay)

Taggant Concept Screening Questions

To aid in its examination of existing and proposed taggant concepts, the committee developed a list of screening questions. These questions were provided to taggant vendors to guide their presentations to the committee, and are shown in Box 2.

BOX 2 QUESTIONS FOR DETECTION AND IDENTIFICATION TAGGANT CONCEPTS

Provide an overview of your taggant concept or technique. Is this taggant concept intended for pre-blast detection, post-blast identification, or both?

How does the technique work? How many unique taggants are possible? What is the information content of the taggant; e.g., how many years of unique identification taggants are possible at the proposed labeling rate? What level or concentration of taggant is needed (to survive a detonation and be collected)? How adaptable is the taggant to different explosive types? What is the cost of the taggant, e.g., cost per pound of taggant, cost of taggant per pound of explosive, other cost impacts such as process changes required?

How are taggant detection, collection, and analysis accomplished? What materials might interfere with detection? Are special personnel training or taggant detection/analysis instruments needed? Are these instruments fixed or portable? What is the response time? What calibration requirements are necessary? What is the false alarm rate/probability of detection? Is the taggant concept (including the detection scheme) equally applicable to detection of concealed explosives on people, in baggage, etc.?

What is the level of development of this concept (ideas, experiments, calculations, field tests, operational experience with stimulants or explosives, etc.)?

What kind of testing has been conducted on this concept?

- Taggant survivability following an explosion? At a measured, high detonation rate?
- Taggant effects on explosive sensitivity?
- Compatibility testing?
- Shelf life or long-term stability of the taggant and effect on explosives?
- Safety testing of the taggant?
- Toxicity testing of the taggant?
- Environmental effects of the taggant; e.g., has a material safety data sheet or premanufacture notification been prepared? What is the environmental persistence of the taggant; e.g., is it biodegradeable?

How does the taggant affect explosive performance?

How is the taggant added to the explosive? If added during manufacturing, what are the effects on the operation and throughput rate? How is proper dispersal of the taggant in the explosive ensured? Is it applicable to both batch and continuous manufacture of explosives?

Are there unique operational, recordkeeping, or training requirements for this taggant concept for either explosive manufacturers or users, or for law enforcement personnel?

How susceptible is this concept to countermeasures, including ease of removal? How susceptible is this concept to cross-contamination?

What is the market for this concept? Are there non-explosive applications?

Taggant Vendors

To date, the committee has held discussions (see Appendix C) with a number of taggant vendors, including the following:

- Bio Traces, Inc.
- Biocode, Inc.
- Cambridge Isotope Laboratories, Inc.
- CDS, Inc.
- Innovative Biosystems, Inc.
- Isotag LLC
- Micro Tracers, Inc.
- Microtrace, Inc.
- SRI International
- Tri-Valley Research

Given below are brief descriptions of each vendor's taggant concept culled from presentations and written materials supplied by the vendors.

Bio Traces, Inc.

Bio Traces, Inc., principally makes instrumentation for detection and quantification of low levels of biomolecules and proposed a taggant concept based on the use of multiphoton detection of appropriate biological and organic molecules.

Biocode, Inc.

Biocode, Inc., uses immunoassay techniques—utilizing engineered antibodies—to specifically identify matching, inert chemicals added to materials as taggants. Biocode currently provides companies in the fuels, inks, pharmaceuticals, chemicals, and other industries with systems for marking or coding their products as a means of detecting and deterring counterfeiting. The company proposed this concept for post-blast identification of explosives.

Cambridge Isotope Laboratories, Inc.

Cambridge Isotope Laboratories, Inc., synthesizes molecules (including some explosive compounds) tagged with stable, non-radioactive heavy isotopes. These isotopes are used mainly for biochemical and environmental trace analysis, but application to tagging of explosives was proposed to the committee.

Chemical Delivery Systems, Inc.

Chemical Delivery Systems, Inc. (CDS, Inc.) develops and manufacturers a number of microencapsulated particle systems for controlled release of solid, liquid, or gaseous materials in various commercial and military products. CDS, Inc., believes that its technologies are applicable and adaptable to both detection and identification taggants for explosives.

Innovative Biosystems, Inc.

Innovative Biosystems, Inc., produces a Gene Tag™ using unique DNA sequences that can be detected in small amounts and amplified using polymerase chain reaction (PCR) methods. The company proposed this method for post-blast identification tagging of explosives. Six-month stability and explosion survivability testing has been conducted by Innovative Biosystems on ammonium nitrate fertilizer.

Isotag LLC

Isotag LLC uses stable (non-radioactive) isotopes to develop "molecular twins" by substituting deuterium for hydrogen in materials to provide an internal identification technique. In some cases, rare-earth elements or rare stable isotopes of common elements are also proposed. Isotag provides the marker compounds, the services to add the tag and take samples of tagged liquids, and the laboratory analytical services to verify the tag presence and tag concentration. It is currently providing tagging services for gasoline supplies of several major oil companies. In a test, Isotag exploded one ton of ANFO tagged with its isotags to verify post-blast survivability and subsequent collection and analysis procedures. The company also has tagged ammonium nitrate at a manufacturing plant.

Micro Tracers, Inc.

Micro Tracers, Inc., produces Microtracers™—colored, uniformly sized iron grit, iron alloy, graphite, stainless steel, or silica gel particles that are analyzed via colormetric techniques—currently used in the animal and poultry feed and building materials industries. They have been used in more than 300 million tons of animal and poultry feed since the 1960s at a reported cost of ten cents per ton. The company has only limited experience in explosives mixing operations, though it believes that its general approach could be adaptable to explosive applications.

Microtrace, Inc.

Microtrace, Inc., manufacturers the Microtaggant® Identification Particle—a 0.6-to 1.1-millimeter, irregularly shaped, multicolor and multilayered plastic particle whose color sequence serves as an identification code. This concept was originally developed and patented by the 3M Corporation in the 1970s. A similar product, called HF 6, is also

manufactured in Switzerland by Swiss Blasting A.G.[15] Microtaggant® Identification Particles were used in explosives during a test program run by the Aerospace Corporation for the ATF in the late 1970s, have been used by the Swiss in more than 50,000 tons of explosives over the last 12 years, and are used in a number of other commercial, antitheft, and property identification applications. Microtrace, Inc., reported current efforts to develop enhanced taggants for pre-blast detection, post-blast identification, and post-blast location of the particles.

SRI International

SRI International has proposed the use of upconverting phosphors—a class of man-made, spherical particle materials that absorb radiation (such as from laser excitation) at a specific wavelength and then emit radiation, via luminescence, at a shorter wavelength. The concept has been proposed for both pre-and post-blast detection of explosives and has been successfully tested by SRI on a small-scale explosive charge. A larger-scale test is planned.

Tri-Valley Research

Tri-Valley Research proposed using rare-earth (lanthanide) element mixtures to tag explosives for identification. Detection and analysis of these ingredients in explosives would be via x-ray fluorescence spectroscopy.

Vendor Information Still to Be Reviewed.

In addition, the committee has received, and begun reviewing, information from a number of other taggant vendors, including the following:

- Centrus Plasma Technologies, Inc.
- MICOT Corporation
- Micro Dot Security Systems Incorporated
- Missouri Scientific
- Natura, Inc.
- Science Applications International Corporation
- Security Features, Inc.
- Tracer Detection Technology Corporation
- University of Missouri-Rolla
- University of Strathclyde, Scotland
- Urenco Nederland B.V., the Netherlands

The committee will continue to evaluate taggant concepts as the study proceeds.

[15] Department of the Treasury. 1995. Proceedings of the International Explosives Symposium. Fairfax, Va.: Government Printing Office.

Taggant Stakeholders

Aside from federal government (ATF, FBI, Federal Aviation Administration (FAA), Secret Service, State, Defense, etc.) and (federal, state, local, and foreign) law enforcement agency interest, a number of other stakeholders have expressed interest and/or noted various concerns about taggant options. To date, the committee has held discussions (see Appendix C) with a number of stakeholder groups, including the following:

- American Pyrotechnics Association (APA)
- Chemical Manufacturers Association (CMA)
- El Dorado Chemical
- Institute of Makers of Explosives (IME)
- International Society of Explosives Engineers (ISEE)
- Law Enforcement Agencies (Los Angeles County Sheriff's Department)
- National Mining Association (NMA)
- National Rifle Association (NRA)
- Sporting Arms and Ammunition Manufacturers' Institute (SAAMI)
- The Fertilizer Institute (TFI)

Given below are brief descriptions of each stakeholder group's position culled from presentations and written materials supplied by the stakeholders.

American Pyrotechnics Association

John A. Conkling, executive director, presented the APA viewpoint. Concerns raised included the possible wide dispersion of taggants into the environment if they are used in fireworks, thus reducing their effectiveness for law enforcement; taggant effects on sales and recordkeeping requirements for consumer fireworks; effects on the economic competitiveness of U.S. fireworks companies faced with significant pressure from imports; and effects on fireworks distribution methods.

Chemical Manufacturers Association

Marybeth Kelliher, manager of international trade, presented the CMA viewpoint about the use of taggants and possible imposition of additional precursor controls on the chemical industry. Her main concerns were product liability and integrity, and she also discussed the effectiveness of taggants for law enforcement. She also noted concerns (costs and man-hours) required to address the possible recordkeeping requirements, and the effects on the competitiveness of the chemical industry, particularly from required reporting as it relates to proprietary business relations.

El Dorado Chemical

Paul Rydlund, vice president of El Dorado Chemical, discussed the production of both high-density, fertilizer-grade and low-density, explosive-grade ammonium nitrate. He also pointed out some of the difficulties associated with possible tagging approaches for this bulk explosive chemical.

Institute of Makers of Explosives

J. Christopher Ronay, president of the Institute of Makers of Explosives, presented the IME viewpoint. The IME endorses the use of detection taggants in plastic explosives and supports a national licensing program for purchasers or possessors of commercial explosives. However, it opposes the use of identification taggants—particularly the Microtaggant® product—in explosive materials, stating that they can pose safety risks, will have an adverse effect on the environment and mined products, will have minimal law enforcement benefits, and will present significant costs and economic competitiveness issues.

International Society of Explosives Engineers

Jeffrey L. Dean, executive director and general counsel, presented the ISEE viewpoint, which included support for a national licensing program for purchasers or possessors of commercial explosives, increased controls on the proliferation of improvised explosives information, support for explosive detection technologies, and the use of detection taggants in plastic explosives.

Law Enforcement Agencies

The committee heard presentations from Lt. Thomas Spencer and Sgt. Howard Rechtshaffen, members of the bomb squad of the Los Angeles County Sheriff's Department. They indicated that while taggant approaches could offer another tool to locate and convict criminals, new legislation requiring taggants would not address the substantial quantities of explosive materials already in the hands of the public. They also indicated a strong preference for pre-blast detection technologies rather than post-blast identification schemes.

National Mining Association

Terry O'Connor, vice president of external affairs for ARCO Coal Company, discussed the concerns of the National Mining Association with the committee. He indicated that the mining industry uses approximately 90% of the more than 4 billion pounds of commercial explosives produced each year. The NMA endorses the use of detection taggants in plastic explosives (such as those endorsed by the International Civil Aviation Organization). However, it opposes broad requirements to include identification taggants in explosive materials because of concerns about safety, mined product

contamination and dispersal issues, cost and economic competitiveness issues, with minimal law enforcement benefit, and adverse effects on the environment.

National Rifle Association

Tanya K. Metaksa, executive director of the NRA Institute for Legislative Action, presented the NRA viewpoint. She noted the strong NRA support for an independent assessment of taggants, particularly for black and smokeless powder, and a strong focus on bombing prevention technologies rather than explosive tagging methods. NRA concerns included safety, cost, possible deleterious effects on firearms, and the utility of taggants to law enforcement.

Sporting Arms and Ammunition Manufacturers' Institute.

James J. Baker, Don Burton, and Ken Green presented the SAAMI viewpoint about the use of taggants in black and smokeless powders. SAAMI concerns included taggant effects on safety, the manufacturing process, distribution, ballistic performance, and cost-effectiveness.

The Fertilizer Institute

Gary Myers, president, and Ford West, vice president, presented the views of the Fertilizer Institute. They also discussed the "Be Aware for America" program—a cooperative program between TFI, the ATF, and others to report suspicious sales of fertilizer-grade ammonium nitrate.

Additional Stakeholders Contacted

In addition, the committee has contacted many other stakeholder groups soliciting written testimony (see Appendix F), including the following:

- American Civil Liberties Union (ACLU)
- American Iron Ore Association
- American Portland Cement Alliance
- American Road and Transportation Builders Association
- Associated Builders and Contractors
- Austin Powder Company
- Dyno Nobel
- Glass Packaging Institute
- Goex, Inc.
- Handgun Control Inc.
- ICI Explosives
- Indiana Limestone Institute
- International Association of Bomb Technicians and Investigators (IABTI)

- International Fertilizer Development Center (IFDC)
- La Roche Industries
- National Industrial Sand Association
- National Lime Association
- National Stone Association
- National Utility Contractors Association
- Other Law Enforcement Agencies
- The Associated General Contractors of America
- The Gypsum Association
- Wiley, Rein & Fielding (representing UNIMIN, a supplier of high-quality silica used in semiconductors)

The information from these groups and others will be assessed as the committee's work continues.

FURTHER WORK BY THE COMMITTEE

As the study continues, the committee will continue to assess existing and additional detection and identification taggant approaches. It will also examine existing and proposed means for desensitizing explosive materials and assess possible controls on precursor chemicals. The committee will also continue to solicit input from the scientific community and affected stakeholders on the issues raised in the committee's charge and on information sources the committee should consider during the course of the study. The results of the committee's work will be published in a final report to be completed by February 1998.

Appendix A

Biographical Sketches of Committee Members

CHAIR

Marye Anne Fox is vice president for research and the M. June and J. Virgil Waggoner Regents Chair in Chemistry at the University of Texas at Austin. Her recent research activities include organic photochemistry, electrochemistry, and physical organic mechanisms. She is a former associate editor of the *Journal of the American Chemical Society.* Previously, she was also the director for the Center for Fast Kinetics Research, vice chairman of the National Science Board, and a member of the Task Force on Alternative Futures for the Department of Energy National Laboratories, the Galvin Committee. Dr. Fox is a member of the National Academy of Sciences and serves on several NAS committees, including the NAS Council Executive Committee and the Committee on Science, Engineering, and Public Policy. She is an NAS Councilor and a former member of the Commission on Physical Sciences, Mathematics, and Applications, and served on the Committee on Criteria for Federal Support of Research and Development. She received a Ph.D. in organic chemistry from Dartmouth College.

VICE CHAIR

Edward M. Arnett is the Reynolds Professor of Chemistry, Emeritus, at Duke University. Dr. Arnett was director of the Duke Surface Science Center and previously held positions at the University of Pittsburgh, Harvard University, Western Maryland College, Max Levy and Company, and the University of Pennsylvania. His research interests include acid base behavior of organic compounds, solvent effects in organic chemistry, organic monolayers, and stereochemistry of aggregation. Dr. Arnett is a member of the National Academy of Sciences. He chaired the National Research Council's Committee on Prudent Practices for Handling, Storage, and Disposal of Chemicals in Laboratories and was a member of the U.S. National Committee for the International Union of Pure and Applied Chemistry. He received his B.S., M.S., and Ph.D. degrees in chemistry from the University of Pennsylvania.

MEMBERS

Alexander Beveridge is the head of the chemistry section of the Vancouver Forensic Laboratory of the Royal Canadian Mounted Police. He has had 29 years of forensic chemistry casework experience. His primary research interest is the analysis of residues from explosives. He is a fellow of the Chemical Institute of Canada and a faculty member of the Open University of British Columbia. Dr. Beveridge earned his B.Sc. degree and Ph.D. in chemistry from Glasgow University and has an MBA from the University of Alberta.

Alan L. Calnan is a professor of law at Southwestern University in Los Angeles, California. Previously, he was an instructor of legal writing at Villanova University, a casualty litigation associate in Philadelphia, and a law clerk for Judge Donald E. Wieand of the Superior Court of Pennsylvania. His research interests focus on tort law, including the use of risk exposure to guide award recovery, differences in demands for corrective justice between corporations and individuals, the convergence of contract and tort law, and development of a uniform theory of civil liability. He is a member of the Pennsylvania State Bar. Mr. Calnan earned a B.A. in history from Kutztown University of Pennsylvania and a J.D. from Syracuse University.

Tung Ho Chen is a research chemist at the U.S. Army Armament Research, Development and Engineering Center at Picatinny Arsenal. His research interests include physical and analytical chemistry of energetic and related materials, multicomponent analysis, and analysis of explosion residues. Dr. Chen is a member of the International Civil Aviation Organization's Ad Hoc Group of Specialists on Detection of Explosives. He is recognized for his work on tagging of plastic explosives. He earned a Ph.D. in chemistry from the University of Louisville.

Herbert S. Eleuterio is a visiting professor in the engineering department at the National University of Singapore. Previously, he held a number of research and management positions at DuPont Company, including director of new technologies and technical director of the Atomic Energy Division. His research expertise includes reaction mechanisms, stereochemistry, polymer chemistry, and nuclear chemistry. He has been the recipient of several honors and awards, including the 1995 National Science and Technology Medal of Singapore and the 1995 Lavoisier Medal for Technical Achievement. He received his Ph.D. in organic chemistry from Michigan State University.

William M. Haynes is director of the Analytical Science Center at the Monsanto Company. He previously held a series of research and research management positions at Monsanto and taught at Southeast Missouri State College. His research interests are in analytical chemistry, including polarographic analysis, ion selective electrodes, and industrial hygiene sampling and analysis. He received his Ph.D. in analytical chemistry from the Oklahoma State University.

Robert. B. Hopler operates Powderman Consulting, Inc. in Oxford, Maryland. He has 35 years of technical and managerial experience in the explosives field with Dyno Nobel, Inc., Ireco, Inc., and Hercules Powder Company. He also served as the Dyno contact with the Federal Bureau of Investigation Explosives Group, Federal Aviation Administration explosives personnel, and the Bureau of Alcohol, Tobacco, and Firearms laboratories. His areas of expertise include ammonium nitrate, packaged explosives, and detonators. He has published numerous papers, taught courses, and made presentations on explosives and detonators. He is a member of the American Institute of Mining Engineers and of the International Association of Bomb Technicians and Investigators, and is the former secretary of the International Society of Explosive Engineers. He received a B.S. and M.S.

in mining engineering, with graduate research on ammonium nitrate/fuel oil blasting agents, from the Missouri School of Mines.

Alexander MacLachlan is retired deputy undersecretary of energy for research management and retired senior vice president for research and development, the DuPont Company. His areas of expertise include management, economics, chemical reactions and kinetics, environment, and health and safety. Dr. MacLachlan is a member of the National Academy of Engineering and currently serves as a member of the Chemical Engineering Peer Committee. He is a member of the NRC Steering Committee on Building an Environmental Management Science Program and previously served on the Steering Committee on Product Liability and Innovation. He received his Ph.D. in physical organic chemistry from the Massachusetts Institute of Technology.

Lyle O. Malotky is the scientific advisor to the associate administrator for civil aviation security at the Federal Aviation Administration. Previously, he was manager of the Aviation Security Technology Branch and head chemical engineer for the Naval Explosive Ordnance Disposal Technology Center. His specialty is terrorist threats and capabilities, aviation security, and explosive detection and analysis. Dr. Malotky has served on numerous international and intergovernmental committees on the application of technology to the battle against terrorism. He received his Ph.D. in polymer science from the University of Akron.

David W. McCall is retired director of the Chemical Research Laboratory at AT&T Bell Laboratories. His educational background is in physical chemistry, and his research expertise is in the areas of nuclear magnetic resonance, diffusion in liquids, polymer relaxation, dielectric properties, and materials for communications systems. He is a member of the National Academy of Engineering and has served on a variety of NRC committees, including the Committee on Polymer Science and Engineering, and is currently a member of the Naval Studies Board. He earned his Ph.D. in chemistry from the University of Illinois.

Douglas B. Olson is associate director for research and development at the Energetic Materials Research and Testing Center at New Mexico Institute of Mining and Technology. His educational background is in physical chemistry, and his research interests include chemical kinetics, combustion, and explosive systems. Dr. Olson has authored or contributed to more than 200 publications and reports, including many on explosives safety and performance testing. He received his Ph.D. in chemistry from the University of Texas.

Jimmie C. Oxley is deputy director of the Gordon Research Conferences, adjunct professor of chemistry at the University of Rhode Island, and a visiting scientist at the Los Alamos National Laboratory. Previously, she was an associate professor in the chemistry department at the New Mexico Institute of Mining and Technology, where she was one of the founding investigators in the Research Center for Energetic Materials, founder and head of the NMIMT thermal hazards group, and developer of a Ph.D. program in explosives chemistry. Her research interests include thermal decomposition of energetic materials,

ammonium nitrate chemistry, and improvised explosive devices. She is the author of more than 40 papers on the subject of energetic materials, the presenter of nearly 100 lectures, and the organizer of numerous national symposia. Dr. Oxley is also a member of the National Research Council's Committee on Commercial Aviation Security. She received her Ph.D. in organometallic chemistry from the University of British Columbia.

Robert M. Pentz is director of the National Law Enforcement and Corrections Technology Center-Western Region, which is operated for the National Institute of Justice by the Aerospace Corporation. In this capacity, he provides technical support services to senior law enforcement officials. In his 27-year career at the Aerospace Corporation, he has primarily been responsible for application of satellite technology to military support architectures. Previously, he worked at Lockheed Missiles and Space Company and the Lawrence Radiation Laboratory. Mr. Pentz earned a B.S. in electrical engineering from the University of California at Berkeley.

Anthony J. Silvestri has retired from positions as vice president of Mobil Research and Development Corporation and general manager for environmental health and safety at Mobil Oil Corporation, where he was responsible for toxicology and product safety functions. During his career with Mobil, he worked in the areas of catalysis, process research and technical service, development of fuels and lubricants, and production of synthetic fuels. He received his Ph.D. in chemistry from the Pennsylvania State University.

Judith Bannon Snow leads the High Explosives Science and Technology group at Los Alamos National Laboratory and is involved with explosives synthesis, formulation, chemical analysis, mechanical properties testing, micro-mechanical physics, nonshock initiation, deflagration to detonation theory, slow combustion, thermal studies, safety assessment, performance assessment, aging studies, and demilitarization of energetic materials. Prior to coming to Los Alamos, she spent 10 years at the Naval Undersea Warfare Center in New London, Connecticut, where she directed the Marine Optics Laboratory. Previously, she did nonlinear optics research in applied physics at Yale University. Dr. Snow has two patent awards and numerous scientific publications in laser spectroscopy, microparticle scattering, and nonlinear optics. She earned a Ph.D. in chemistry from Wesleyan University (Connecticut) and was a Sloan Fellow at the Stanford University Graduate School of Business, where she received an M.S. in management.

Frank H. Stillinger is a member of the technical staff at Bell Laboratories, Lucent Technologies. His research interests include statistical mechanics of liquids and amorphous solids, phase transition theory, theoretical methods in quantum chemistry, and computer simulation. He is a member of the National Academy of Sciences and has served on several NRC committees, including the Committee on Mathematical Challenges from Computational Chemistry, which he chaired. He earned his Ph.D. in chemistry from Yale University.

Andrew E. Taslitz is a professor of law at the Howard University School of Law, where he teaches a variety of courses, including criminal law, criminal procedure, and criminal

evidence law. Previously, he was a visiting legal writing instructor at Villanova University School of Law; a Litigation Department associate for the firm of Schnader, Harrison, Segal & Lewis; and an Assistant District Attorney in the Philadelphia District Attorney's Office. The focus of his more than 15 years of writing and practice has been on the cultural, political, economic, and practical implications of prosecuting violent crime. He is the author of *Constitutional Criminal Procedure* (1997) and numerous articles and book chapters on scientific evidence, police investigatory practices, and jury reasoning processes. He is a member of the American Association of Law Schools' Evidence Section Advisory Board and of the American Bar Association (ABA) Criminal Justice Section's (CJS) Committee on Rules of Criminal Procedure and Evidence, and he is co-chair of the ABA CJS Committee on Race and Racism in the Criminal Justice System. He received a J.D. from the University of Pennsylvania Law School.

Appendix B

Detailed Statement of Task

The study required by this statement of work will be performed following contract award. The study will address four basic areas and they will be worked at simultaneously. The study will consider the viability of adding tracer elements to explosives for the purpose of detection, the viability of adding tracer elements to explosives for the purpose of identification, the feasibility and practicability of rendering inert common chemicals used to manufacture explosives materials, and the feasibility and practicability of imposing controls on certain precursor chemicals used to manufacture explosive materials.

The study will focus on issues in science and technology, with the goal of framing the issues for furnishing a report that provides a clear description of the technical options that exist. The report will provide advice that will facilitate decisions by officials of the Bureau of ATF on which to base recommendations to Congress. It will also clearly set forth any opinions and findings obtained as a result of consultation with other Federal, State and local officials and regulated industry members of fertilizer research centers. Once the study is initiated, discussions will be held with Bureau officials at three (3) month intervals to report progress.

Task 1. Viability of Adding Tracer Elements to Explosives for Detection. The purpose of this task is to explore and define methods, materials and technologies that are available today, as well as in research and development, that might be used to enhance the detectability of concealed explosives.

Subtask 1.1. Materials recommended as candidates for inclusion as detection elements shall not pose a risk to human life or safety.

Subtask 1.2. Materials recommended for inclusion as detection elements shall not substantially impair the quality and reliability of explosives for their intended lawful use. At least three organizations that are capable of conducting testing to validate the study fundings shall be identified.

Subtask 1.3. The study will evaluate the utility to law enforcement, to include susceptibility to countermeasures, problems of cross-contamination, and ease of detection, analysis and survivability, of all materials which will provide substantial assistance that are recommended as candidates for inclusions in explosives as detection elements.

Subtask 1.4. Materials recommended for inclusion as detection elements shall not have a substantial adverse effect on the environment.

Subtask 1.5. The study shall include an assessment of costs associated with the addition of tracer elements which will not outweigh the expected benefits of all materials that are recommended as candidates for inclusion in explosives.

Task 2. Viability of Adding Tracer Elements to Explosives for Identification. The purpose of this task is to explore and define methods, materials and technologies that are available today, as well as in research and development, that might be utilized to enhance the traceability of illegal explosives after detonation.

Subtask 2.1. Materials recommended as candidates for inclusion as identification elements shall not pose a risk to human life or safety.

Subtask 2.2. Materials recommended for inclusion as identification elements shall not substantially impair the quality and reliability of explosives for their intended lawful use. At least three organizations that are capable of conducting testing to validate the study findings shall be identified.

Subtask 2.3. The study will evaluate the utility to law enforcement, to include susceptibility to countermeasures, problems of cross-contamination, and ease of identification, analysis and survivability, of all materials which will provide substantial

assistance that are recommended as candidates for inclusion in explosives as identification elements.

Subtask 2.4. Materials recommended for inclusion as identification elements will not have a substantial adverse effect on the environment.

Subtask 2.5. The study shall include an assessment of costs associated with the addition of tracer elements.

Task 3. Feasibility and Practicability of Rendering Common Explosive Chemicals Inert. The purpose of this task is to explore and define methods, materials and technologies that have been used in the United States and internationally to render common explosives chemicals inert or less explosive, explore and define methods, materials and technologies available today to render common explosives chemicals inert or less explosive, as well as explore and define materials and technologies that are in a research and development phase that might be utilized to render common explosives chemicals inert or less explosive.

Subtask 3.1 The study shall identify, prioritize and establish a list of chemicals to be known as *common explosive chemicals,* in order of the most widely used in illegal explosives to the least widely used.

Subtask 3.2. Materials, methods and technologies recommended as candidates for rendering common explosive chemicals inert or less explosive shall not pose a risk to human life or safety.

Subtask 3.3. Materials, methods and technologies recommended as candidates for rendering common explosive chemicals inert or less explosive shall not substantially impair the quality and reliability of explosives for their intended lawful use. At least three organizations that are capable of conducting testing to validate the study findings shall be identified.

Subtask 3.4. Materials, methods and technologies recommended as candidates for rendering common explosive chemicals inert or less explosive shall be evaluated to determine their utility to law enforcement, susceptibility to countermeasures, potential problems of cross-contamination, and ease of identification, analysis and survivability.

Subtask 3.5. Materials, methods and technologies recommended as candidates for rendering common explosive chemicals inert or less explosive shall not have a substantial adverse effect on the environment.

Subtask 3.6. The study shall include an assessment of costs, to include agronomic, economic, and social, and compare those costs to the expected benefits of all materials, methods and technologies that are recommended as candidates for rendering common explosive chemicals inert or less explosive.

Subtask 3.7. The study shall include an assessment of the effect on similar products of the industry if materials, methods or technologies used to render common explosive chemicals inert or less explosive are utilized with respect to some common explosive chemicals but not others.

Task 4. Feasibility and Practicability of Imposing Controls on Certain Precursor Chemicals. The purpose of this task is to explore the feasibility and practicability of imposing controls on certain precursor chemicals used to manufacture explosive materials.

Subtask 4.1. The study shall identify, prioritize and establish a list of chemicals to be know as *precursor chemicals,* in order of the most widely used in illegal explosives to the least widely used.

Subtask 4.2. The study shall identify and rank, in order of ease of implementation, the options available for imposing increased controls on precursor chemicals.

Subtask 4.3. The study shall evaluate the potential reduction of explosives incidents from imposing increased controls on precursor chemicals.

Subtask 4.4. The study shall evaluate the utility to law enforcement that would accrue by imposing increased controls on precursor chemicals.

Subtask 4.5. The study shall analyze benefits and compare the benefits expected from implementing enhanced controls to the costs, both increased manufacturing costs as well as increased costs at the retail level, associated with imposing increased controls on precursor chemicals.

Subtask 4.6. The study shall assess the effect on similar products of the industry if increased controls were placed on some products but not others.

Subtask 4.7. The study shall consider volunteer programs such as Be Aware for America endorsed by the ammonium nitrate industry and the potential that other similar voluntary approaches could be developed.

Appendix C

Committee Meetings

FIRST MEETING.

November 25–26, 1996
Presentations:
Study Background and Expectations from Sponsor
Sonny Wilson and Ray Conrad, Bureau of Alcohol, Tobacco, and Firearms (ATF)
Bomb Scene Investigation Procedures
Mike Bouchard, ATF
FAA Explosive Detection Program
Lyle Malotky, Committee Member

SECOND MEETING AND "WORKSHOP ON TECHNICAL DETAILS RELEVANT TO THE USE AND EFFECTIVENESS OF TAGGANTS"

January 13–15, 1997
Presentations:
International Civil Aviation Organization (ICAO) Work on Plastic Explosive Taggants *(in Executive Session)*
Tung Ho Chen, Committee Member
Pilot Test for the Identification Tagging of Explosives: Description and Results
Gary Fuller, former Aerospace Corporation staff
Taggant concept-Microtrace, Inc.
William J. Kerns and Charles W. Faulkner
Taggant concept-Micro Tracers, Inc.
David A. Eisenberg

NOTE: Because of the sensitive nature of some of the information, some presentations to the committee were not delivered in open session. These are indicated by "*(in Executive Session).*"

Taggant stakeholder-National Mining Association
Terry O'Connor and Bobby J. Jackson
Taggant stakeholder-Institute of Makers of Explosives
J. Christopher Ronay
Taggants and Explosive Detection Research
David Boyd, National Institute of Justice
Taggant stakeholder-A Law Enforcement Perspective
Lt. Thomas Spencer and Sgt. Howard Rechtshaffen, Los Angeles County Sheriff's Department
Taggant concept-CDS, Inc.
Victor A. Cranich
Taggant concept-SRI International
James Colton
Taggant concept-Isotag LLC
Manny Gonzalez and Dale Spall
Taggant concept-Cambridge Isotope Laboratories, Inc.
Daniel Bolt
Taggant concept-Tri-Valley Research
John Pearson and Robert M. Pearson
Taggant concept-Bio Traces, Inc.
Andrzej Drukier and James Wadiak
Taggant concept-Biocode, Inc.
Frank Angella
Taggant concept-Innovative Biosystems, Inc.
Keith Stormo
Taggant stakeholder-Sporting Arms and Ammunition Manufacturers' Institute (SAMMI)
James Baker, Don Burton, and Ken Green
Taggant stakeholder-National Rifle Association (NRA)
Tanya Metaksa and Mark Barnes

Taggant stakeholder-Chemical Manufacturers Association (CMA)
Marybeth Kelliher
Taggant stakeholder-American Pyrotechnics Association (APA)
John Conkling and Julie Hechtman
Taggant stakeholder-International Society of Explosives Engineers (ISEE)
Jeffrey L. Dean

THIRD MEETING

March 3–5, 1997
Presentations:
JASON committee reports on explosive detection *(in Executive Session)*
Paul Horowitz, Harvard University and member of the JASONs
Briefing on definition of terms (types of explosives) and precursor materials *(in Executive Session)*
Jimmie Oxley, Committee Member
Briefing on types of bombers, tactics, materials, and methods of fabrication *(in Executive Session)*
Greg Carl, FBI
Explosive manufacturing, chain of ownership, and impurity profiling between batches
Paul Rydlund, Vice President, El Dorado Chemical
The Fertilizer Institute
Gary Myers, President, and Ford West, Vice President
Technical Steering Working Group (TSWG) on Counter-Terrorism explosive detection programs *(in Executive Session)*
Mike Jakub, State Department and TSWG
Explosive desensitization program *(in Executive Session)*
Joe Hemeriel, Army Research Laboratory
Navy work on desensitizing of explosive materials *(in Executive Session)*
Ruth Doherty, Naval Surface Warfare Center-Indian Head

Chemical Weapons Convention (CWC) controls on precursor chemicals *(in Executive Session)*
Will Carpenter, Monsanto (retired) and Robert Mikulak, Arms Control and Disarmament Agency
Drug Enforcement Agency (DEA) controls on precursor chemicals *(in Executive Session)*
John Mudri, DEA
Chemical industry flows *(in Executive Session)*
Jeff Terry, Chemical Manufacturers Association

FOURTH MEETING

March 24–25, 1997
Presentations:
Holston Army Ammunition Plant Marking of Military C-4 Explosive *(in Executive Session)*
Jerry Hammonds, Holston Army Ammunition Plant
Law Enforcement Perspectives *(in Executive Session)*
Richard Saferstein (retired), New Jersey State Police Laboratory
Cobalt-60 Detection Taggant Evaluation *(in Executive Session)*
Kenneth Moy, Special Technologies Laboratory
Types of Explosive Materials Used in Improvised Explosive Devices *(in Executive Session)*
Rick Strobel, ATF Laboratory
Taggant Usefulness in an Actual Bombing Case *(in Executive Session)*
Dan Boeh, ATF Investigator
Landmine Sniffing Technologies *(in Executive Session)*
Regina Dugan, Defense Advanced Research Projects Agency
Ammonium Nitrate Manufacturing
Robert Hopler, Committee Member
Status of the Commercial Explosives Industry
Robert Hopler, Committee Member

Legal Issues in Actual Bombing Cases
James W. Jardine, Q.C., Barrister and Solicitor
Behavorial science: Deterrent Effects on Crime
Daniel Nagin, Carnegie Mellon University
Risk Assessment
James Lamb, Jellinek, Schwartz and Connolly, Inc.
Measuring Costs and Benefits
Richard Mudge, Apogee Research, Inc.
Site Visits:

On March 26, members of the committee visited both the ATF (Rockville, Md.) and FBI (Washington, D.C.) forensic science laboratories associated with bomb scene investigations.

Appendix D

Language of the Antiterrorism and Effective Death Penalty Act of 1996

TITLE VII-CRIMINAL LAW MODIFICATIONS TO COUNTER TERRORISM SEC. 732. MARKING, RENDERING INERT, AND LICENSING OF EXPLOSIVE MATERIALS.

(a) STUDY.

(1) IN GENERAL.-Not later than 12 months after the date of enactment of this Act, the Secretary of the Treasury (referred to in this section as the "Secretary") shall conduct a study of

(A) the tagging of explosive materials for purposes of detection and identification;

(B) the feasibility and practicability of rendering common chemicals used to manufacture explosive materials inert;

(C) the feasibility and practicability of imposing controls on certain precursor chemicals used to manufacture explosive materials; and

(D) State licensing requirements for the purchase and use of commercial high explosives, including

(i) detonators;

(ii) detonating cords;

(iii) dynamite;

(iv) water gel;

(v) emulsion;

(vi) blasting agents; and

(vii) boosters.

(2) EXCLUSION.-No study conducted under this subsection or regulation proposed under subsection (a) shall include black or smokeless powder among the explosive materials considered.

(3) New prevention technologies: In addition to the study of taggants as provided herein, the Secretary, in consultation with the Attorney General, shall concurrently report to the Congress on the possible use, and exploitation of technologies such as vapor detection devices, computed tomography, nuclear quadrupole resonance, thermal neutron analysis, pulsed fast-neutron analysis, and other technologies upon which recommendations to the Congress may be made for further study, funding, and use of the same in preventing and solving acts of terrorism involving explosive devices.

(b) CONSULTATION.

(1) IN GENERAL.-In conducting the study under subsection (a), the Secretary shall consult with

(A) Federal, State, and local officials with expertise in the area of chemicals used to manufacture explosive materials; and

(B) such other individuals as the Secretary determines are necessary.

(2) FERTILIZER RESEARCH CENTERS.-In conducting any portion of the study under subsection (a) relating to the regulation and use of fertilizer as a pre-explosive material, the Secretary of the Treasury shall consult with and receive input from non-profit fertilizer research centers.

(c) REPORT.-Not later than 30 days after the completion of the study conducted under subsection (a), the Secretary shall submit a report to the Congress, which shall be made public, that contains

(1) the results of the study;

(2) any recommendations for legislation; and

(3) any opinions and findings of the fertilizer research centers.

(d) HEARINGS.-Congress shall have not less than 90 days after the submission of the report under subsection (c) to

(1) review the results of the study; and

NOTE: Title VII was amended on September 28, 1996 (Department of Defense Appropriations Act, 1997). Changes are shown as bold text.

(2) hold hearings and receive testimony regarding the recommendations of the Secretary.

(e) REGULATIONS.

(1) IN GENERAL.-Not later than 6 months after the submission of the report required by subsection (c), the Secretary may submit to Congress and publish in the Federal Register draft regulations for the addition of tracer elements to explosive materials manufactured in or imported into the United States, of such character and in such quantity as the Secretary may authorize or require, if the results of the study conducted under subsection (a) indicate that the tracer elements

(A) will not pose a risk to human life or safety;

(B) will substantially assist law enforcement officers in their investigative efforts;

(C) will not substantially impair the quality of the explosive materials for their intended lawful use;

(D) will not have a substantially adverse effect on the environment; and

(E) the costs associated with the addition of the tracers will not outweigh benefits of their inclusion.

(2) EFFECTIVE DATE.-The regulations under paragraph (1) shall take effect 270 days after the Secretary submits proposed regulations to Congress pursuant to paragraph (1), except to the extent that the effective date is revised or the regulation is otherwise modified or disapproved by an Act of Congress.

(f) Special Study:

(1) In general.--Notwithstanding subsection (a), the Secretary of the Treasury shall enter into a contract with the National Academy of Sciences (referred to in this section as the Academy) to conduct a study of the tagging of smokeless and black powder by any viable technology for purposes of detection and identification. The study shall be conducted by an independent panel of 5 experts appointed by the Academy.

(2) Study elements.--The study conducted under this subsection shall

(A) indicate whether the tracer elements, when added to smokeless and black powder

(i) will pose a risk to human life or safety;

(ii) will substantially assist law enforcement officers in their investigative efforts;

(iii) will impair the quality and performance of the powders (which shall include a broad and comprehensive sampling of all available powders) for their intended lawful use, including, but not limited to the sporting, defense, and handloading uses of the powders, as well as their use in display and lawful consumer pyrotechnics;

(iv) will have a substantially adverse effect on the environment;

(v) will incur costs which outweigh the benefits of their inclusion, including an evaluation of the probable production and regulatory cost of compliance to the industry, and the costs and effects on consumers, including the effect on the demand for ammunition; and

(vi) can be evaded, and with what degree of difficulty, by terrorists or terrorist organizations, including evading tracer elements by the use of precursor chemicals to make black or other powders; and

(B) provide for consultation on the study with Federal, State, and local officials, non-governmental organizations, including all national police organizations, national sporting organizations, and national industry associations with expertise in this area and such other individuals as shall be deemed necessary.

(3) Report and costs.--The study conducted under this subsection shall be presented to Congress 12 months after the enactment of this subsection and be made available to the public, including any data tapes or data used to form such recommendations. There are authorized to be appropriated such sums as may be necessary to carry out the study.

CONFERENCE LANGUAGE ACCOMPANYING THE ANTITERRORISM AND EFFECTIVE DEATH PENALTY ACT OF 1996

Section 732-House amendment sections 301 and 801 recede to Senate sections 708 and 905, with modifications. This section directs the Treasury Secretary to provide to the Congress a study of the feasibility of tagging explosives and precursor chemicals, for the purpose of tracing the explosives back to the manufacturer after an explosion. The study would also evaluate the feasibility of imposing controls on the sale and distribution of certain of those chemicals. Black or smokeless powder is excluded from the study. The section requires input from non-profit fertilizer research centers in the Treasury Secretary's conduct of the study. The section also requires the Treasury Secretary to conduct a study of the licensing requirements applicable in the various states for the purchase and use of commercial high explosives. The phrase “commercial high explosives” is defined, by way of illustration, to include “detonators, detonating cards, dynamite, water gel, emulsion, blasting agents, and boosters.” This section also requires the Treasury Secretary to report the results of the study to Congress, together, if deemed necessary, with recommendations for regulation. The Secretary is authorized to promulgate regulations requiring the inclusion of tracing taggants in explosive materials if the taggants will not endanger human life or safety, will substantially assist law enforcement, and are cost-effective. The regulations promulgated pursuant to this authority shall go into effect if Congress does not act within 270 days of the publication of the regulations in the Federal Register.

Appendix E

Working Bibliography

THE STUDY

"NRC Panel Enters the Fight Over Tagging Explosives." Science. January 24, 1997; pp. 474–475 .

Rouhi, M. "Research Council to Study Taggants." Chemical and Engineering News. September 9, 1996; pp. 10–11 .

"Tagging Explosives: Safety and Cost Dominate Debate." Chemical and Engineering News. January 20, 1997; pp. 9–10 .

GENERAL

Barbash, F. 1996. "London Police Seize 10 Tons of Presumed IRA Explosives: 1 Dead, 5 Arrested in Raids on Alleged Terrorist Group." The Washington Post. September 24, page A12 .

Cooper, K. 1995. "Few Countermeasures Seen Against Homemade Bombs." The Washington Post. June 14, page A4 .

Department of the Treasury, Bureau of Alcohol, Tobacco and Firearms. 1995. Arson and Explosives: Incidents Report 1994. ATF P 3320.4. Washington, D.C.

Kitfield, J. 1996. "Freelance Terrorism Hard to Halt." National Journal. July 6, pages 1483–1484 .

National Research Council. 1986. The Embassy of the Future: Recommendations for the Design of Future U.S. Embassy Buildings. Washington, D.C.: National Academy Press.

National Research Council. 1988. Protection of Federal Office Buildings Against Terrorism. Washington, D.C.: National Academy Press.

National Research Council. 1995. Protecting Buildings from Bomb Damage: Transfer of Blast-Effects Mitigation Technologies from Military to Civilian Applications. Washington, D.C.: National Academy Press.

Schleifer, Y. 1996. "The Explosion of Bombs: What's Behind the Startling Upsurge in Criminal Blasts?" The Washington Post. August 4, page C4 .

Technical Support Working Group (TSWG) of the National Security Council's Interagency Working Group on Counterterrorism (IWG/CT). Briefing slides.

U.S. Department of Justice. National Institute of Justice Research Plan 1995–1996.

EXPLOSIVES (GENERAL)

"Advances in Analysis and Detection of Explosives," Jehuda Yinon (editor), Proceedings of the 4th International Symposium on Analysis and Detection of Explosives, September 7–10, 1992 , Jerusalem, Israel.

Anon. The Terrorist's Handbook.
Available On-line
Cooper, Paul and Kurowski, Stanley. Introduction to the Technology of Explosives. VCH Publishers, 1996 .
Coursen, D. 1992. Explosion and Explosives, McGraw-Hill Encyclopedia of Science and Technology, 7th Edition, McGraw-Hill: New York.
FBI. 1993 Bomb Summary.
FBI. 1995 Bombing Data.
FBI Explosives Unit, Bomb Data Center. 1994. "1994 Bombing Incidents." General Information Bulletin 95-2 .
General Accounting Office. 1996. Terrorism and Drug Trafficking: Technologies for Detecting Explosives and Narcotics.
Hopler, Robert, 1997. "Today's Commercial Explosives Industry: Trends in Products and Operations." Washington, D.C.: Dyno Nobel Inc.
"Inspectors Say Stopping Mail Bombs Impossible." USA Today. January 14, 1997 .
"It's in the Mail." The New Yorker. January 25, 1997 .
List of Working Papers from ICAO Ad Hoc Group of Specialists on the Detection of Explosives.
"Mail Bombs," NPR radio, January 15, 1997 .
Oxley, J. 1993. "Non-Traditional Explosives: Potential Detection Problems." Terrorism and Political Violence 5 (number 2): 30–47 . See also, Oxley, J. "The Chemistry of Explosives," "The ABCs of Explosives," and "Case History of an Ammonium Nitrate Emulsion Accident."
Yinon, Jehuda and Zitrin, Shmuel. 1993. Modern Methods and Applications in Analysis of Explosives. John Wiley and Sons.

BLACK POWDER AND SMOKELESS POWDER.

Raber, L. 1996. "Clinton Drops Demand for Explosives Taggants." Chemical and Engineering News. August 5, page 7 .
Why All Gun Owners Should Fear Taggants: The Truth About Taggants. http://pw2.netcom.com/~wooffer/taggants.html

TAGGANTS (GENERAL)

Chen, T. 1995. "History of Military Explosives Tagging Efforts-ICAO Tagging of Plastic Explosives," p. 41 in Explosives Symposium, September 18–22, 1995 , Fairfax, Va.: Department of the Treasury, Bureau of Alcohol, Tobacco, and Firearms.
Crawford, M. 1996. "Anti-Terrorism Tools Get Fast PTO Action." New Technology Week. August 12, page 10 .
Department of the Treasury. 1995. Preliminary Proceedings of the International Explosives Symposium. Fairfax, Va.: Government Printing Office.
Office of Technology Assessment (OTA). 1980. Taggants in Explosives. Washington, D.C.: Government Printing Office.

Port, O. 1996. “An End to Anonymous Bombs? Even the NRA May Not Be Able to Stop IDs for Explosives.” Business Week. August 12, pages 84–85 .
Rouhi, M. 1995. “Government, Industry Efforts Yield Array of Tools to Combat Terrorism.” Chemical and Engineering News. July 24, pages 10–19 .
Rouhi, M. 1995. “How One Chemist's Outrage Sparked a Counterterrorism Invention.” Chemical and Engineering News. July 24, pages 13 .
Schwartz, J. 1995. “Technology Used to Tag Explosives Gets Second Look After Bombing.” The Washington Post. May 7, page A8 .

TAGGANTS (VENDORS)

Information from taggant vendor: Biocode, Inc.
Information from taggant vendor: Cambridge Isotope Laboratories, Inc.
Information from taggant vendor: Innovative Biosystems Inc.
Information from taggant vendor: Isotag LLC.
Information from taggant vendor: Microtrace, Inc.
Information from taggant vendor: Micro Tracers, Inc.
Information from taggant vendor: SRI International.
Information from taggant vendor: Tri-Valley Research.

TAGGANTS (STAKEHOLDERS)

Follow-on information from the Institute for Makers of Explosives on tagging program costs.
Information from the World Wide Web: “Why All Gun Owners Should Fear Taggants,” http://pw2.netcom.com/~wooffer/taggants.html .; “Fact Sheet: Tagging and Taggants for the Detection and Identification of Explosives, Smokeless Propellants, and Black Powder,” http://www.carkba.org/ncrkba/nccda_taggant.html .; and “Taggant Information,” http://www.hodgdon.com/taggants.htm .
Information provided by ARES Incorporated
Written testimony and follow-on information from the National Rifle Association, and an article in American Rifleman about the NRA's testimony to the committee.
Written testimony from Amit Roy, International Fertilizer Development Center.
Written testimony from George Ryan, American Iron Ore Association.
Written testimony from Robert Bingham, Dyno Nobel, Inc.
Written testimony from the Chemical Manufacturers Association and follow-on information on regulatory costs.
Written testimony provided by the Glass Packaging Institute.

TAGGANTS FOR DETECTION

Blasting Cap Tagging Schemes. JASON report JSR-86-825, 1986 .
Detection of Liquid Explosives. JASON report JSR-88-850, 1988 .
Detection of Plastic Guns. JASON report JSR-87-825, 1987 .

Detonator Tagging Using Multi-Photon Detection. Science Applications International Corporation. 1996 .
Lyle Malotky. 1991. Review of Potential Non-Vapor Marking Agents for Plastic Explosives.
National Research Council. 1993. Detection of Explosives for Commercial Aviation Security. Washington, D.C.: National Academy Press.
National Research Council. 1996. Airline Passenger Screening. Washington, D.C.: National Academy Press.
Office of Technology Assessment. 1991. Technology Against Terrorism: The Federal Effort. Washington, D.C.: Government Printing Office.
Office of Technology Assessment. 1992. Technology Against Terrorism: Structuring Security. Washington, DC: Government Printing Office.
Special Technologies Laboratory. 1996. Cobalt-60 as a Marking Agent.
Special Technologies Laboratory. 1994. Future Tagging Program.
Tagging Explosives for Detection. JASON report JSR-89-750, 1994 .
Tracer Detection Technology Corporation. Company Information.

TAGGANTS FOR IDENTIFICATION

A white paper on glass microsphere taggants from the University of Missouri at Rolla.
Aerospace Corporation. 1980. Identification Tagging Pilot Test for Packaged, Cap-Sensitive Explosives: Final Report. ATR-80 (5860-03)-1ND. Washington, D.C.
Freeman, Bruce. 1996. Explosive Tagging with Stable Isotopes. Centrus Plasma Technologies, Inc.
Information from MICOT Corporation on its Micro-Component Tracer product.
Information from Natura, Inc., on its luminescent chemical tagging approach.
Information from Urenco Nederland B.V. on use of stable isotopes as potential taggants.
Information on an Explosive Tagging Proposal by Dr. Vincent Calder.
Information on Identispheres provided by Mo-Sci Corporation.
Information on Micro Dots provided by Micro Dot Security Systems Incorporated.
Selective Tagging of Explosives Using Surface Enhanced Resonance Raman Scattering (SERRS) as a Detection Technique. W. Smith and P. White, University of Strathclyde.
Wu, C. 1996. “Tagged Out: New Markers for Explosives May Lay Old Safety Questions to Rest.” Science News, volume 150, September 14, pages 168–169 .

DESENSITIZING EXPLOSIVES [1]

Hopler, Robert, Ammonium Nitrate/Fuel Oil (ANFO) Blasting Agents: Background of Development, Manufacture, and Use. Dyno Nobel, Inc.
Garant, R. 1995. “Oklahoma City: How Easy Is It?” The Risk Advisory, May/June .

[1] Several relevant papers are also included in the proceedings from the September 1995 ATF/International Explosives Symposium.

Gorman, Christine. 1995. “How Garden-Variety Fertilizer Becomes Killer Bombs.” Time. volume 145, number 18, May 1 .
Sparta, Inc. 1995. Making Commercial Ammonium Nitrate Unsuitable for Terrorist Use.

CONTROLS FOR PRECURSOR CHEMICALS

Department of the Treasury, Bureau of Alcohol, Tobacco, and Firearms. 1990. Explosives Law and Regulations.
Green, S. 1996. Preventing Illegal Diversion of Chemicals: A Model Statute. Department of Justice.
Green, Sherry, National Institute of Justice. 1993. Preventing Illegal Diversion of Chemicals: A Model Statute.
Hassan, F. 1996 “Explosives Producers Face Lawsuits.” Chemical Week, volume 158, number 25, June 26, page 18 .
Hassan, F. 1996. “Product Liability: Fertilizer Makers Face Bombing Suit.” Chemical Week, volume 158, number 12, March 27, page 12 .
National Institute of Justice. 1993. Controlling Chemicals Used to Make Illegal Drugs: The Chemical Action Task Force and the Domestic Chemical Action Group.
The New Gun Week. 1996. “Minnesota Activist Blasts Clinton's Stand on Taggants.” October 10, page 12 .
Office of Technology Assessment. 1993. The Chemical Weapons Convention: Effects on the U.S. Chemical Industry.
Rouhi, M. 1996. “Product Liability Could Be the Real Issue with Taggants.” Chemical and Engineering News. August 26, page 38 .
Sevick, James R., National Institute of Justice. 1993. Precursor and Essential Chemicals in Illicit Drug Production: Approaches to Enforcement.
Swansiger, W., Shepodd, T., and Phillips, M. 1994. Development of Techniques for Tagging Precursor and Essential Chemicals. Sandia National Laboratory.

Appendix F

Taggant Stakeholder Letter

December 31, 1996

Taggant Stakeholder Organization
Attn: Jane Doe,
President
Address City, State Zipcode

Dear Ms. Doe:

The National Research Council has formed the Committee on Marking, Rendering Inert, and Licensing of Explosive Materials to study the scientific and technical issues related to (a) the viability of adding tracer elements to explosives for the purpose of detection, (b) the viability of adding tracer elements to explosives for the purpose of identification, (c) the feasibility and practicability of rendering inert common chemicals used to manufacture explosives materials, and (d) the feasibility and practicability of imposing controls on certain precursor chemicals used to manufacture explosive materials. The study goal is to frame the issues and furnish a report that provides a clear description of the technical options that exist. The report will provide advice that will facilitate decisions by officials of the Bureau of Alcohol, Tobacco, and Firearms on which to base recommendations to Congress. An interim report will be published in April 1997 and a final report in February 1998.

The committee has just started its work and has already begun to examine a number of issues and concerns raised by various stakeholder groups. To aid the committee in its deliberations, we invite you or your representative to submit a written statement outlining your position on the subject of the study. We also welcome your suggestions for information sources or issues you feel the committee should consider during the course of its study. In addition, the committee will invite as many stakeholder groups as possible to meet with the committee in person to provide further elaboration.

We appreciate your assistance and look forward to your reply. I have enclosed a brochure to give you more information on the committee. Please contact Tracy D. Wilson, at (202) 334-1671/2156, fax (202) 334-2154, or twilson@nas.edu or xplo@nas.edu for further details.

Committee on Marking, Rendering Inert, and Licensing of Explosive Materials

Appendix G

Acronyms and Abbreviations

ACLU	American Civil Liberties Union
ANFO	Ammonium nitrate and fuel oil
APA	American Pyrotechnics Association
ATF	(Bureau of) Alcohol, Tobacco, and Firearms
BCST	Board on Chemical Sciences and Technology
CMA	Chemical Manufacturers Association
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
IABTI	International Association of Bomb Technicians and Investigators
ICAO	International Civil Aviation Organization
IFDC	International Fertilizer Development Corporation
IME	Institute of Makers of Explosives
ISEE	International Society of Explosives Engineers
NAS	National Academy of Sciences
NAE	National Academy of Engineering
NMA	National Mining Association
NMAB	National Materials Advisory Board
NRA	National Rifle Association
NRC	National Research Council
OTA	Office of Technology Assessment
PCR	Polymerase chain reaction
SAAMI	Sporting Arms and Ammunition Manufacturers' Institute
TFI	The Fertilizer Institute
TNT	2,4,6-Trinitrotoluene