Chapter I

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INTRODUCTION

At the request of the Senate Committee on Governmental Affairs, the **Office of** Technology Assessment has undertaken an analysis of the proposal to mandate the use of taggants in **explosive materials manufactured for commercial use.** A "tag-**gant" is a material that might be added to explosives and gunpowders* at the time of manufacture, as an eventual aid to law enforcement.** This study assesses the existing taggant technology **in order to assist Congress in its decision whether to adopt legislation which would require taggants in explosives and gunpowders.**

Two different kinds of taggants are being developed for possible incorporation in chemical explosives, and it **has been proposed that both be required. Identification taggants are designed to survive the detonation** of an explosive, and to be retrieved from the debris. **They would contain a code identifying the batch of explosives or gunpowder used in a particular bombing. The intent of those advocating the development of such taggants is that law enforcement officers investigating a criminal bombing would retrieve identification taggants and decode them, could then begin their investigation knowing what kind of explosive material had been used, and would be able to obtain a list of the last legal purchasers of these explosives and gunpowders. At the present time the leading contender for an identification taggant is a color-coded microscopic plastic chip which has been developed by** the 3M Co.

Detection taggants are designed to be sensed by a suitable detection machine even when contained in a package. The intent of those developing detection taggants is that detection machines at airports, public building entrances, and other appropriate sites would signal any effort to introduce explosive materials into the area. **In facilities not normally protected by such devices, portable detection sensors could be used to search the facility in response to a threat. The leading contender for a detection taggant is a microcapsule which would emit small quantities of a vapor whose molecules are so distinctive that a suitable sensing instrument (which is under parallel development) could detect a parts-per-trillion concentra-**tion.

The Bureau of Alcohol, Tobacco, and Firearms (BATF) of the Department of the Treasury, which is the executive agency that has jurisdiction over most crimes involving high explosives, has sponsored a program to develop taggants, Most of the effort has been carried out or supervised by the Aerospace Corp., under contract to BATF. Neither identification taggants nor detection taggants have been fully developed and tested; the detection taggant effort is less advanced than the identification taggant effort.

Legislation proposed in the U.S. Senate would make it unlawful (in the words of S. 333) // . . . for any person or persons to manufacture any explosive material which does not contain . ." both detection taggants and identification taggants, and would ***require*** that manufacturers and distributors keep records showing the distribution chain for each batch of explosive material that carried a separate

*The term gunpowder includes black and smokeless powders and pyrodex (a registered trademark of thePyrodex Corp) a black powder substitute

identification taggant code. (Similar legislation has been proposed in the House of Representatives.) The Secretary of the Treasury would issue regulations implementing this requirement, and such regulations would be phased in as testing was completed and taggants became available in sufficient quantity.

At hearings on this proposal, representatives of the explosives and gunpowder industries and others expressed opposition to this proposal on the grounds that:

- **it is premature to consider explosives tagging legislation while development and testing of taggants have not been completed;**
- **taggants may be unsafe, since they would require adding a foreign substance to the explosive materials;**
- **a taggant program would be extremely costly; and**
- **a taggant program would not, in fact, have much utility for law enforcement.**

Proponents of a taggant program have countered that:

- **taggants are inert materials, no more unsafe than current additives to explosives and gunpowder;**
- **a taggant program need not be unduly costly; and**
- **bombings are extremely difficult crimes to prevent or solve using existing methods, and taggants would provide an extremely useful tool to law enforcement agenices.**

The Senate Committee on Governmental Affairs has requested that OTA review the available data on explosive taggant technology, and conduct an assessment which would address;

1. the safety of adding taggants to explosives;
2. the postdetonation survivability and recoverability of identification taggants;
3. the cost impact of a taggant program on the explosives industry and users;
4. the utility of a taggant program to law enforcement;
5. the effects on cost and utility of excluding certain explosive materials from the taggant program;
6 the removal of taggants from tagged explosives; and
7 alternatives to a taggant program.

The text of the request letter is included as appendix A.

The proposal to require that taggants be added to commercial explosives at the time of manufacture has aroused intense controversy. While OTA believes that this report will serve to narrow many of the areas of controversy, there are a number of issues on which the available data do not permit a scientifically conclusive finding. OTA has therefore made a number of judgments based on the available evidence where conclusive proof was lack ing. In some cases these judgments, and the reasoning underlying them, have proved unpersuasive to one side or another in the controversy. Therefore, the final section of this chapter calls attention to the major areas in which one or more affected parties may disagree with the OTA findings.

Research Approach

In order to assess the impacts of a taggant program, a two-stage approach has been necessary. As the first stage, an analysis has been made of the safety and technical efficacy of the taggants at the current state of development, since cost and utility are moot points if the taggants are not safe and do not work. As the second stage, an assumption has been made that the taggants work and are safe and a parametric analysis of costs and utility made as a function of the specific implementation plan.

Due to severe time constraints, OTA did little original research; instead, an intensive review of existing research was supplemented by discussions with manufacturers, distributors, and users of explosives and gunpowders, and with law enforcement personnel and experts

on terrorism. Table 1 summarizes the major sources consulted.

I n addition, OTA sent a questionnaire to approximately 950 members of the International Association of Chiefs of Police (IACP) asking them to assess the utility of taggants. (The IACP membership list was chosen because it constituted a broad cross section of the law enforcement community.) The questionnaire was sent to a random sample of the IACP members, and the low response rate (about 15 percent) probably created a bias towards those with interest in, and knowledge of, the subject. (A possible misconception may have been introduced by the explanatory material introducing the questionnaire, which inadvertently indicated that identification taggants could identify the last legal purchaser of explosives used in a bombing, rather than identifying a list of last legal purchasers.) The results of the questionnaire, interpreted with considerable caution, are integrated into the analysis in chapter VI, and reported in detail in appendix B.

OTA also directed a series of tests on the recoverability of the 3M identification taggant. The Aerospace Corp. had conducted a large number of laboratory tests on the survivability of the 3M identification taggants, but the only information on the recovery of taggants under field conditions came from poorly documented demonstrations and training tests, conducted by BATF, the Federal Bureau of investigation, and other organizations. These tests, and others conducted by the Institute of Makers of Explosives, had produced conflicting and contradictory results. OTA planned and supervised a limited series of tests of the post-detonation recovery process of taggants from automobiles. The results of these tests are integrated into the findings, and described in detail in appendix C.

Table.–Major Sources of Information

Manufacturers
Explosives manufacturers (Du Pent, Atlas, Independent, Goex, Hercules)
Gunpowder manufacturers (Hercules, Goex, Olin, Pyrodex)
Manufacturer of identification taggants (3M Co.)

Trade organizations
Institute of Makers of Explosives(I ME)
Sporting Arms and Ammunition Manufacturers' Institute (SAAMI)

Consumer organizations
National Rifle Association (NRA)
National Muzzle Loaders Association (NM LA)

Organizations developing a taggant program
Bureau of Alcohol, Tobacco, and Firearms of the U S. Treasury Department (BATF)
Aerospace Corp. (BATF contractor)

Organizations involved in taggant research
Management Sciences Associates
Institute for Defense Analyses
Lawrence Livermore Laboratories

Explosives and gunpowder distributors
B, F Hodgdon
Tri-State Explosives

Gunpowder retailer
The Bullet Hole

Explosives users
Copper mines (Bingham Canyon open pit mine. Crow Fork underground mine)

Explosives users–continued
Coal Mine (Webster Coal Co.)
(Quarries (Tri-State, Rockville Crushed Stone)
Construction firm (Guy Atkinson)
Blasting contractor (Tri-State Explosives)

Law enforcement personnel
New York, N.Y,
San Mateo County, Calif,
Dallas-Fort Worth Airport, Tex,
Summit County, Ohio
Washington, DC.

Experts on terrorists and terrorism
Experts from foreign and domestic law enforcement agencies
Writers on the subject (Dr. Ernest Evans, Dr. Rona Fields, Dr. Robert Kupperman)

Foreign law enforcement sources
West Germany
England
Ireland
Interpol

U.S. Federal agencies
Federal Bureau of Investigation
Federal Avation Administration
Bureau of Mines
Department of Transportation
U.s. Army (Corps of Engineers, Criminal Investigation Division, Development and Research Command)

SOURCE Office of Technology Assessment

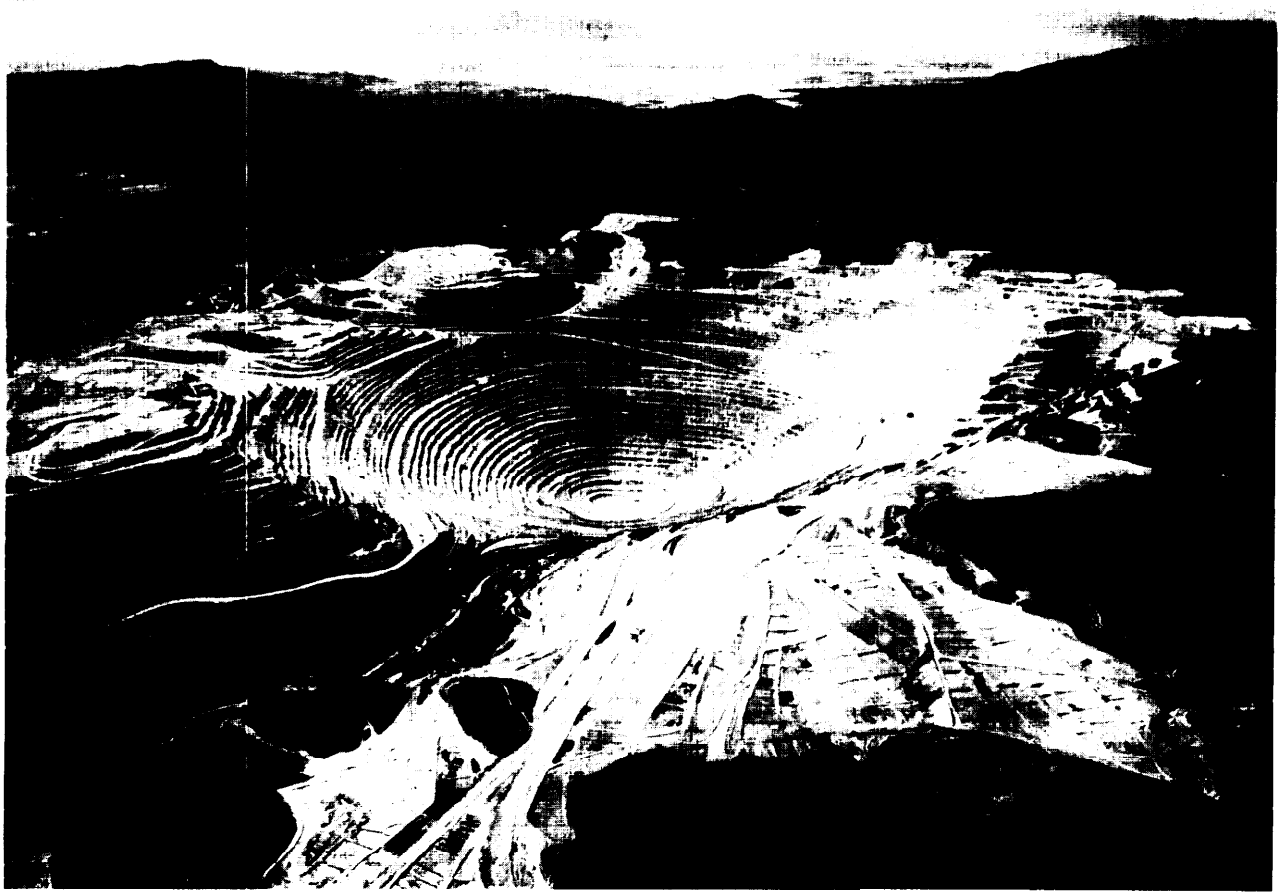

Photo credit Kennecott Copper Co.

[explosives are utilized extensively at the Bingham Canyon open pit copper mine

Some Project Limitations

There are three general limitations to the completeness of this analysis of the proposal to legislate the use of taggants in explosive materials. **The primary limitation is caused by the preliminary nature of the taggant research–** much data are simply not available. Additional information is req Jired on all aspects of the analysis—technical efficacy, safety, cost, and utility. Table 2 summarizes the research conducted to date.

Preliminary safety testing has been conducted on only a portion of the materials to which identification taggants would be added, and compatibility testing has barely begun with detection taggants. Evidence has been found of reactivity (using high taggant concentrations at elevated temperatures) between the 3M identification taggants and one type of smokeless powder, as well as one booster material. This reactivity creates a presumption of incompatibility. Until this presumed incompatibility is resolved, taggants cannot be safely added to these explosive materials. Resolution of the problem may result in significant changes in the taggants, requiring a new set of compatibility tests and perhaps changing the basis of the cost analysis. If the problem is resolved, more data still need to be generated. The lack of data on long-term effects, in terms of safety, stability, and performance, especially on products such as gels and slurries, is par-

Photo credit U S *Department of fhe* Treasury

Photograph of automobiles utilized in the OTA taggant recovery test

Table 2.–Current State of Taggant Research[a]

	ID taggants		Detection taggants
	Compatibility	Survival recovery	Compatibility
Cap sensitive.	Preliminary finished	Preliminary finished	Preliminary underway
Boosters	Preliminary underway–compatibility problem identified	Preliminary underway	Testing initiated
Detonators . .,	Prelimmary underway	Preliminary underway	Testing initiated
Blastlng agents ., ., .,	None	None	None
Detonating cord ., . .	None	Testing initiated	Testing initiated
Black powder ., ...	Preliminary finished	Preliminary underway	Preliminary underway
Smokeless powder	Preliminary underway–compatibility problem identified	Preliminary underway	Testing initiated
Military explosives ., .,	None	None	None

[a]As of mid-January 1980

SOURCE Office of Technology Assessment

ticularly important. As a result of this uncertainty, not even preliminary indications of safety are possible at this time, much less the demonstrations recessary before a taggant proposal could safely be implemented.

While preliminary research has been conducted on the survivability and recoverability of the 3M identification taggants, only a portion of the explosive materials which might be tagged was tested, and that research is poorly documented. Hundreds of possible detection taggants have been screened to yield five candidate materials, but detailed testing of the properties of those materials is barely underway. Similarly, three candidate detection sensors have been identified, and limited Laboratory testing of preliminary or "breadboard" models completed. Methods of air sampling are also at a preliminary stage. Thus, estimates of technical efficacy can only be made on the basis of preliminary data.

As a result of the pilot test program, reasonable data are available for the analysis of the cost impact of adding taggants during the manufacture of cap-sensitive high explosives, at least for those companies which participated in the program. The data, however, on the cost impact of adding taggants during the manufacture of the other types of explosive materials (for exalmple, gunpowder) are less adequate. While firm estimates of the cost of unencapsulated identification taggants are available from 3M under a variety of implementation conditions, little data are available for the cost of encapsulated identification taggants (a more likely baseline case) or for the cost of detection taggants. Only the grossest estimates have been made of recordkeeping costs, and the estimates by both the proponents and opponents are open to some questions of objectivity. Rule-of-thumb engineering estimates have been made for the candidate sensor systems costs, but the accuracy of those estimates cannot be very precise as neither production rate, tc)tal production, nor specifications have been established.

So far, identification tagging of explosives has played a part in only one criminal case that has reached a courtroom. (Those investigating and prosecuting the case considered evidence from taggants very helpful.) Quantification of the utility of taggants (identification as well as detection) is therefore simply not possible, particularly given the inadequacy of bombing statistics. Experience with the date-shift code (which facilitates tracing of undetonated explosives) provides useful data, as does the experience of foreign countries, but the available information on the utility of taggants is preponderantly qualitative in nature.

A second general limitation to the completeness of the analysis, imposed by limits on available time and resources, **is that only a limited sample of the population concerned with the study could be contacted.** As a result, cost data derived from a detailed analysis of one or two companies have been assumed to be representative of an entire segment of an industry, such as underground coal mining or retail sale of gunpowders. Similarly, processes for adding taggants, reworking of waste material, quality control, compatibility testing, and storage, which are applicable to a segment of the manufacturers of explosive materials, have been assumed to be universal for the purpose of generating cost estimates. A more serious manifestation of the limited sample size is that in-depth discussions of the utility of identification and detection taggants to law enforcement and security personnel could only be held with a small number of organizations. As the bomber threat varies considerably from one part of the country to another, it is difficult to generalize the results of those discussions.

The third limitation on the analysis is caused by the language of the draft legislation, S. 333. The bill calls for tagging of all "explosive materials," which does not appear practicable if the phrase is strictly interpreted to include the tagging of blasting agents that are mixed the same day they are detonated, and otherwise offers no guidance for the implementation regulations which the Secretary of the Treasury would promulgate.

SUMMARY OF FINDINGS

This assessment distinguishes between an evaluation of the present state of development of taggants and a projection of the cost and utility of a taggant program if and when the necessary development and testing are successfully completed. A detailed evaluation of the development status of the identification and detection taggants is contained in chapter I I 1. A crucial factor in the development status evaluation concerns the safety of adding taggants to explosives; the safety and general compatibility analysis is contained in chapter **IV. OTA** then separately evaluated the cost and utility of a program to add taggants to commercial explosive materials. For this analysis, it was assumed that the baseline identification and detection taggants had successful ly completed the development process, including a resolution of the safety issues. These analyses are contained, respectively, in chapters V and VI. Details of these and other findings are given in chapter 11. The principal findings are shown in table 3 and briefly summarized below.

Taggant Utility

Assuming, for purposes of analysis, that stability questions are successfully resolved and that technical development is successfully completed, both identification taggants and detection tag-

Table 3.–Stimmary of Current Status of Taggants

	Idenhf!cation taggants	Detection taggants
safety		
Dynamites, gels. slurries,	No change in sensitivity, stability	No reported data; testing initiated
Black powder.	No change in sensitivity, stabddy	No reported data; testing initiated
Smokeless powder	Reactivity with Herco' powder observed, incompatibility presumed	No reported data, testing initiated
Booster materials	Reactivity with Composition B observed, incompatibility presumed	No reported data; testing initaited
Blasting agents .,	No data	No data
Performance	Limited testing	No data
Survivability		
Favorable conditions.	Yes	N/A
Fire ., .,	Probable	N/A
Confinement :	Insufficient data	N/A
Recoverability		
Field recovery .,	Probable if survive	N/A
Field reading	Unlikely	N/A
Laboratory reading	Almost all conditions	NIA
Sensor development.	N/A	Early stages
utility		
Low-value targets	Little	Virtually none
High-value targets, no countermeasures	High	High
High-value, Including countermeasures	High, due to Increased risks	High for all but most sophisticated bombers

Cost, $ millions/year	Identification	Detecioon	Both
Low-level program (ID tag code for each product changed each year. ANFO excluded)[a].	$15	$22	**$30**
Baseline program (ID tag code for each product changed for each date/shift, ANFO excluded) .	25	25	45
High-level program (ID tag changed for each 10,000-lb batch, ANFO Included) . .	215	65	268

N/A not applicable
aThese programs are defined in detail in ch v

SOURCE Off Ice of Technology Assessment

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gants would be useful law enforcement tools against most terrorist and other criminal bombers. Their utility against certain types of bombers would probably be quite high; their utility against the most sophisticated of terrorists and professional criminals is open to question.

- **Data on the number and kinds of bombings committed are dispersed and inconsistent.** Table 4 gives an idea of the magnitude of the problem; its significance is discussed in chapter II and the derivation of the figures in appendix F. OTA diligently sought to find or reliably derive data from which one could calculate the number of bombings that a taggant program would solve or deter, and found this an impossible task.
- **Criminal bombings are committed by a wide range of perpetrators, including both "individuals and groups.** It is helpful to group criminal bombers into four categories, which differ greatly in their motivation, skill, training, resources, and ability to respond to a changing enforcement environment. They are defined and their proportions estimated in table 5. Note that despite the tendency for some groups to claim "credit" for a bombing, a motive was established for only 23 percent of the bombings reported to BATF in 1977 and only 38 percent in 1978; table 5 is based on the assumption that the distribution of motives was the same for the numerous incidents in which law enforcement officials were unable to assign a motive.
- **Identification taggants would facilitate the investigation of almost all significant criminal bombings in which commercial explosives were used.** Due to the need for laboratory involvement in the taggant recovery process, the taggants would probably not enter into investigations of bombings that produce no casualties and little property damage.
- **Detection taggants would be very effective in protecting those high-value targets where protection by detection taggant sensors is feasible.** The improvement in protection of such potential targets would be quite substantial. However, most current bombings take place against targets that are unlikely to be protected by detection taggant sensors.
- **Adding taggants to blasting agents would have some utility, but the incremental utility would be small compared to the utility of tagging cap-sensitive high explosives, gunpowders, and detonators (and the incremental cost would be high).** A taggant program that did not include gunpowders would be of relatively limited utility as pipe bombs filled with gunpowder are used in a substantial number of

Table 4.–Minimum Bombing Incidents Statistics Summary a

Item	BATF 1977	BATF 1978	FBI 1977	FBI 1978
Explosive bombings, number	1,037b	896b	867	768
Undetonated explosive bombs, number	319	287	118	105
Incendiary bombings, number	339	446	248	349
Unignited incendiary bombs, number	81	71	85	79
Criminal accidents, number	21	67	–	–
Property damage from bombings, millions of dollars c d	$ 10	$ 17	$ 9	$ 9
Injuries c	180	185	162	135
People killed by bombings c	38	23	22	18

a BATF reported 3.177 total Incidents in 1977 and 3,256 in 1978 Total incidents include accidents, threats deized and recovered explosives, and hoaxes as well as axtual explosives and incendiary bombings The OTA stud/ was concerned only with explosive bombings
b of these 953 in 1977 and 787 m 1978 were against substantial targets
c Includes both explosive and incendiary bombings OTA was unable to obtain Separate figures for the number of criminal accidents, injuries, deaths, and property damage caused by Incendiary bombs Incendiary bombs and bombings would not be affected by taggant program
d Actual value probably considerably higher due 10 lack Of data file updates

SOURCE *SOURCE:* BATF 1978 Explosives Incidents Report. FBI *Uniform Crome Report. Bomb Report.* 1978 See app F for a dicussion of the derivation of these figures

Table 5.–Proportions of Bombings Attributed to Groups of Perpetrators (average for years 1974-78)

Bomber type	Characteristics	Percentage of bombings	Estimated number in 1978a
Terrorists	Highly motivated, varied skill levels, act in groups, continuing involvement	12	107
Criminals	Varied motivations, varied skill levels, act alone or in small groups, repeated activities, specific targets	11	98
Mentally disturbed	Highly motivated, poorly trained, act alone, seldom repeat crimes	38	340
Vandals and experimenters,	Limited motivation, poor training, limited resources, do little damage	39	348

asee app F for dervations of these estimates

SOURCE FBI data

bombings; it only high explosives were tagged, criminals could shift to pipe bombs rather easily.

- **The utility of both identification and detection taggants would be decreased because some bombers would take countermeasures.** Explosives experts have suggested a number of possible countermeasures to the proposed taggant technology which would be available to those bombers with the requisite knowledge and resources. Most available countermeasures would increase the risk to the bomber of personal injury or arrest, or decrease the reliability of the bomb. Law enforcement officials and experts on terrorism agree that most bombers would not utilize the available countermeasures. A taggant program would retain substantial utility even though some criminal bombers would attempt countermeasures, and these countermeasures would be effective whenever they were carried out with sufficient knowledge and skil1.
- **The utility of taggants to law enforcement personnel is not adequately quantifiable,** due to the paucity of data on taggants or similar control mechanisms, the difficulty of analyzing the currently collected statistics on bombings, and the fact that it is difficult to quantify how much any single clue adds to an investigation or prosecution. Generally speaking, law enforcement techniques are seldom subjected to cost-benefit analysis, and the data which exist do not lend themselves to such effort. Similarly, OTA was unable to quantify the deterrent effect taggants may have, although the apparent effectiveness of airport screening procedures in reducing the number of hijacking attempts suggests that detection taggants may have a considerable deterrent value.

Taggant Cost

The cost of a taggant program would vary enormously depending on the nature of the pro= gram. Costs are likely to be reasonable if and only if any taggant legislation requires regulations to be written in a way that weighs costs against considerations of law enforcement utility.

- **A low-level taggant program,** in which a unique taggant species would be used to identify each year's production of a specific product, and **800** detection sensors would be deployed, **would cost $3o million per year.**
- **A "baseline" program identified by OTA (described in detail in ch. V) would cost approximately $45 million per year,adding** approximately 12 percent to the cost of cap-sensitive explosives and slightly under **8** percent to the cost of gunpowder, Cap-sensitive high explosives, boosters, detonators, detonating cord, and gunpowder would be tagged. A unique taggant species would be used for a shift's production of each product and size. Fifteen hundred detection sensors would be deployed. The bulk of this cost would eventually fall on users of explosives and on users of products produced with the aid of explosives; the costs of detection taggant sensors would presumably be borne by the owners or users of protected facilities. It is not expected that costs of this magnitude would lead to any major shifts in the patterns of production and use of explosives.
- **Separate baseline identification and detection taggant programs would cost approximately $25 million per year each,** including public overhead costs.
- **A high-level program,** in which a unique taggant would be used for each 10,000-lb batch of explosives or 2,000-lb batch of gunpowder, in which blasting agents would be tagged, and in which 5,000 detection sensors would be deployed, **would have an estimated cost of** *$268* **million per year.**
- **The cost estimates assume that the taggant material costs do not differ appreciably from current estimates for mass-produced taggants.** Chapter V discusses the causes and the extent of the uncertainties surrounding these cost estimates.

Technical Development

The development of taggants is not yet complete. Further developmental effort, particularly resolution of the questions regarding the stability of smokeless powder and cast boosters to which taggants have been added, and successful completion of a variety of tests, would be required before it would be appropriate to begin adding taggants to commercial explosives.

- **The identification taggants developed by 3M appear to survive the detonation of commercial explosives under ideal conditions. Con**finement and fire may adversely affect survival, although test data is very limited. Recovery of the taggants appears to be a function of the specific incident conditions (weather, type of target, firefighting activities) as well as the training and care of the field and laboratory investigators. A trained team can probably recover debris from which a laboratory can separate taggants under most incident conditions.
- **There is little basis for judging whether the detection taggant system,** based on machine sensing of microencapsuiated vapors, which appears to show promise under laboratory conditions, **would function reliably under conditions of mass production and field use,** or how soon sucn a system would be available.

R

Safety

The tests so far conducted create a presumption that there are no incompatibilities between the 3M identification taggant and dynamites, slurries, gels, emulsions, or black powder. Nevertheless, a full-scale qualification program is necessary before taggants can be added to all such materials.

- **The addition of 3M identification taggants to one brand of smokeless powder (Herco" *) and one variety of booster material (Composition B) produces a chemical reaction at elevated temperatures and high taggant concentrations.** The taggants must be considered incompatible with such explosives unless or until: 1) the composition of the taggant is changed in a way that eliminates this chemical reaction, *or 2)* a determination is made that the reaction takes place only under circumstances that can be prevented from arising in commercial production, distribution, and use. If the incompatibility remains, then Congress could, if it chose, require that these particular explosives either be themselves modified, withdrawn from the market, or granted an exemption from tagging. (OTA believes that exemption of smokeless powders could significantly diminish the utility of a tagging program; exemption of cast boosters would diminish this utility to a somewhat lesser extent.) If compatibility is established, completion of a qualification program would still be necessary.
- **There is little evidence regarding the safety of detection taggants, or of the combination of identification and detection taggants, as testing has only recently been initiated and no results have yet been reported.**
- **Analysis, and the limited testing so far conducted, indicate that the performance of explosive material would not be degraded by the addition of taggants.** However, preliminary tests suggest that abnormally high concentrations of taggants might decrease the ballistic performance of smokeless powder. Testing, including long-term effects, would be necessary, however, before the question could be fully resolved.

*A registered trademark ot Hercules, Inc

CONTINUING CONTROVERSIES

Some of OTA'S findings have been challenged by one or more of the participants in the controversy that surrounds the proposal to require that commercial explosives be tagged, The nature of these challenges is outlined here

Significance of Compatibility Testing to Date

A large number of tests have been carried out to determine whether the 3M identification taggant is compatible with commercial explosives. More tests are required, and the Aerospace Corp. (under contract to BATF) is sponsoring a continuing testing program. The tests completed to date are described in chapter IV.

OTA **found that the testing done to date creates a reasonable presumption that the 3M identification taggant is compatible with dynamites, gels, slurries, emulsions, and black powder. On the other hand, there is evidence of increased reactivity, and thus a presumption of incompatibility, with at least one form of smokeless powder, and at least one cast booster composition.** It is not yet possible to arrive at presumptions about the compatibility of the 3M taggant with blasting caps or detonating cord, or about the compatibility of detection taggants with any commercial explosive. OTA further found that, even for products such as dynamites where no evidence of incompatibility exists, further testing is required before it can be definitely concluded that taggants are compatible with, and can safely be added to, al l such explosives.

The Aerospace Corp. takes the view that the compatibility tests with dynamites, gels, slurries, emulsions, and black powder generally are sufficient to permit implementation of a program to tag these substances. Aerospace recognizes that there is a need for Mine Safety and Health Administration approval of tagged permissible dynamites, that final qualification of production-line 3M taggants must be made to ensure that they match those used in the pilot test, and that the black powder ballistics testing should be reviewed and possibly augmented. However, Aerospace points out that while not every test has been conducted with every brand of every explosive, the program successfully carried out was designed by industry and was considered sufficiently thorough so that several major firms were willing to distribute pilot quantities of tagged explosives through their normal commercial distribution channels. With regard to smokeless powders and cast boosters, Aerospace takes the view that no safety hazard has been demonstrated, but that the failure of the tagged explosive to pass certain extreme tests means that compatibility has yet to be demonstrated, and the possibility that some changes will be required to ensure safety cannot be ruled out.

Representatives of the explosives industry take the view that taggants cannot be considered compatible with explosives until all the testing that ought to be carried out has been successfully completed. They maintain that until safety has been conclusively demonstrated, it would be premature to consider whether to legislate a requirement that commercial explosives be tagged. Explosives industry representatives also make a distinction between the pilot program so far carried out and normal commercial production. They maintain that the tagged explosives manufactured under the pilot program received unusual care and attention during the manufacturing process, and were distributed to a limited number of selected distributors. The manufacturers also believe that the terms of the pilot program relieved them of liability for accidental explosions due to taggants, a point which the Aerospace Corp. contests. Some explosives industry representatives take the view that the failure of the mixture of taggants with one brand of smokeless powder and one cast booster composition to pass one safety test means that the 3M taggant should be viewed as unsafe unless or until it is redesigned, and point out that any such redesign would require repeating all other tests previously carried out.

Countermeasures

It **is clear that it would be possible for terrorists or other criminals to take measures to defeat the impact of a tagging program, by making or acquiring untagged explosives. OTA** found that such countermeasures would require a considerable degree of technical knowledge and skil1, and that in most cases countermeasures would either require the commission of an additional crime (with some added risk of apprehension), or else manufacturing or modifying explosives in a way that would risk either a premature explosion or a misfire of the bomb. **The law enforcement experts whom OTA consulted predict that many terrorists and other criminals would probably not avail themselves of countermeasures that were theoretically available to them.**

Representatives of the explosives industry take the view that one should assume that an available countermeasure will in fact be employed. They point out that the most sophisticated bombers, who are most likely to be willing and able to employ countermeasures, are those which may pose the greatest threat. They fear that a taggant program would fail to be effective because of widespread use of countermeasures, and that law enforcement officials would then wish to counter the countermeasures by extending the range (and hence the cost) of the taggant program.

OTA has noted a consistent pattern of disagreement on this point. Experts in the explosives industry and Government explosives experts almost unanimously believe that countermeasures exist which would enable bombers to evade the effects of a taggant program, whether the countermeasures take the form of removal of taggants from tagged explosives, use of untagged blasting agents, theft of explosives, fabrication of "homemade" explosives, or use of incendiary devices. Law enforcement experts, and experts on terrorists and terrorism, almost unanimously believe that most bombers, including terrorists, would fail to take the steps necessary to evade a taggant program, even though the necessary equipment and knowledge is not too difficult to obtain. A possible analogy is the effectiveness of the program to counter aircraft hijacking; since that program began, thousands of weapons have been detected each year, while there have been no cases of aircraft hijacked with weapons smuggled onboard, despite the fact that mechanisms can be postulated for smuggling weapons past the screening apparatus. OTA believes that while countermeasures to a taggant program would be available and would be effective if correctly used, most bombers would not make effective use of such countermeasures. **OTA believes that taggants, if successfully developed, could have significant law enforcement utility even if some terrorists or other criminals successfully employed countermeasures.**

Blasting Agents (ANFO)

Blasting agents are the most widely used type of commercial explosive; the most common type of blasting agent consists of mixtures of prilled ammonium nitrate and fuel oil; these explosives are collectively known as ANFO. ANFO can be mixed in a factory, or mixed directly at the site where blasting is to take place. Ammonium nitrate fertilizer can be mixed with ordinary fuel oil to create a rather insensitive ANFO.

Because of the very large volume of ANFO that is used commercially, a tagging program which included ANFO would be substantially more costly than one from which ANFO was excluded. Chapters I I and V present detailed information on this point. One of the reasons for the wide gap between BATF and the explosives industry cost estimates for a tagging program is that the industry read the draft legislation (S. 333) as requiring that ANFO and other blasting agents be tagged, while BATF was planning for a taggant program that would not include ANFO.

Representatives of the explosives industry have taken the position that exclusion of ANFO would greatly diminish the law enforcement utility of a taggant program, because bombers could and would use untagged ANFO in place of tagged, cap-sensitive explosives or tagged gunpowders. OTA believes that it is in-

deed the case that an effective bomb, suitable for almost all criminal or terrorist purposes, can be manufactured from ANFO if the criminal has adequate time, skill, knowledge, and motivation. **The critical area about which judgments differ is the extent to which terrorists and other criminals would in fact make use of ANFO bombs if other commercially available explosive materials were tagged.**

OTA does not consider it appropriate to describe here how one would go about manufacturing an AN FO-filled bomb. The process involves more steps, a greater number of materials and components, and more opportunities for error than a bomb made from a cap-sensitive explosive; however, it would be easier and safer than fabrication of a bomb from "raw chemical s." The ANFO commercially available in the United States would not be reliably detonated by an ordinary detonator (#8), even in a pipe bomb. ANFO can be readily detonated by using a small high-explosive booster, but such boosters would be tagged, and a large booster or several small ones would make an efficient bomb without the use of ANFO. ANFO can also be detonated using materials that would not be tagged (if the bomber knows how to wire them), but an ANFO pipe bomb is substantially harder to detonate than a smokeless-powder pipe bomb or a stick of dynamite.

Photo *credit U.S Department of the Treasury*

A typical pipe bomb. Such bombs are normally filled with black and smokeless powder, but a bomber with sufficient knowledge and skill could use ANFO

At the present time, ANFO is seldom used in pipe bombs despite the fact that it is cheaper and, if properly detonated, considerably more energetic than smokeless powder. Whether the tagging of cap-sensitive high explosives and powders would in fact lead many criminals to switch to the use of ANFO is a question that cannot be answered with certainty. **However, as in the case of other countermeasures, OTA has found that explosives experts tend to expect that criminals would switch to ANFO, while law enforcement experts and experts on terrorism tend to doubt that this would happen in many cases.**

Survivability and Recovery of Taggants

The testing done to date on the conditions under which identification taggants would in fact survive an explosion, and surviving taggants could in fact be recovered, is not adequate to sustain firm conclusions. Much of the available data is anecdotal rather than systematic. Part of the problem is that it is difficult to arrange for testing under realistic but controlled conditions. Faced with inadequate and somewhat contradictory data, particularly with respect to the recovery question, OTA arranged for a very limited test program to supplement the previous tests; appendix C reports on this effort.

OTA feels that prior testing supports the presumption that taggants would probably survive most bomb detonations under most conditions. However, survivability decreases with the size of the explosive charge and its power. The survivability of individual taggants in large explosive charges or in extremely powerful explosives (such as booster material and military explosives) has not been demonstrated. Pressed pellets, fabricated from the individual taggants, do survive the detonation, but recovery has not been adequately demonstrated, and compatibility tests on pellets remain to be accomplished. **OTA found that the taggants surviving most bombs could probably be recovered under most conditions. However, field investigators might well find it impossible to separate the taggants from the debris, identify in-**

dividual taggants, and read the codes in the field; instead the field team would have to gather debris likely to contain taggants, and a laboratory could thereafter separate and read the taggants. Such a laboratory need not be elaborate, and could be installed in a truck if onsite taggant reading was considered desirable.

BATF maintains that, on the contrary, the 3M identification taggant can be recovered and read in the field by investigators who have received a reasonable amount of training.

Some industry representatives maintain that there is considerable doubt as to whether taggants would actually survive and be recovered from a bomb. Such doubts should, they hold, be cleared up before attempting to reach any judgment about the utility of an explosives tagging program.

Development Time

OTA believes that the further development and testing that would be required before an identification taggant program could be implemented are likely to take until 1983. If an identification taggant program were legislated early in 1980, it would be at least late 1984 before all commercial explosives could be manufactured with taggants. Even if the sensor development and detection taggant programs are successful, OTA feels it would be at least 1985 before full implementation could occur. BATF maintains that these times are too pessimistic.

CONGRESSIONAL OPTIONS

Given the present state of development of taggants, OTA'S data and analysis appear to be consistent with any of three possible courses of action. (No significance is intended in order of listing.)

- **Pass legislation requiring taggants, and** set up a procedure to determine if and when the technical development and testing have progressed to a point where implementation can begin. Given the active involvement of BATF in the development of taggants, it may be inappropriate for the implementation decision process to reside in the Treasury Department.
- **Defer legislative action on taggants, but encourage BATF to continue taggant development,** with a view to consideration of legislation when development and testing are complete.
- **Take no legislative action on taggants, and encourage** the executive branch to search for other ways of improvin, the effectiveness of law enforcement against terrorist and other criminal bombers.