APPENDIX E–SUITABILITY OF ANFO AS A FILLER FOR CRIMINAL BOMBS

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Congress of the United States
Office of Technology Assessment
Washington D. C. 20510

Attention: Mr. Peter Sharfman

Reference: Your Letter of 11 January 1980

Dear Sir:

Referring to questions put to me by Mr. David Garfinkle of Science Applications, Inc. about the initiation and the damage potential of explosive devices loaded with ANFO, I would like to answer you with the following statements.

ANFO generally consists only of ammonium nitrate and fuel oil at a weight ratio of about 95 to 5, but may be used to designate other types of ammonium nitrate based explosives. The density is approximately 0.78 gicms, the energy density E. = 2.9 X 103 J\cm3, and the ratio of specific heats of the gaseous products is I' "= 2.554. Under ideal conditions (i.e. quantities of several hundred kg and a strong initiation source) ANFO detonates at a rate of 5 km\s 'with a Chapman-Jouguet pressure (at the shock front) of 55 kbar. In small samples (e.g. 10 to 20 kg) . even if confined, the detonation velocity is considerably lower, depending on confinement conditions and initiation, and typically between 1.9 and 2.8 km/s. The shock front pressure in these cases is also considerably lower than 55 kbar. Samples with small dimensions and negligible confinement will not detonate at all, (e.g. cylindrical samples in thin plastic confinement 5 cm or less in diameter, or unconfined layers of 5 cm or less in thickness) .

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The ANFO commercially sold and used in the U.S.A. can generally not be initiated by a detonator only. A “booster” made of about **50 to 500 g** of high explosives such as Composition C4, which can be initiated by a detonator only, is generally used to start the detonation. A criminal use of this type ANFO in quantities of 1 or 2 kg does not seem reasonable since the efficiency of a destructive explosive device under these circumstances would generally not be significantly improved beyond that resulting from the booster alone.

It is possible, however, to produce high explosives similar to ANFO which can be detonated by a detonator only. Some ANFO sold and used in the Federal Republic of Germany for mining and quarrying purposes has this property called “cap sensitivity”. It is also possible to modify the composition of the blasting agent such that it becomes cap sensitive, e.g. by replacing the fuel oil by hydrazine hydrate. The sensitivity of ANFO can be increased by certain additives, e“g” aluminum powder or potassium perchlorate. In some cases, the sensitivity of the ANFO-like blasting agent can be increased by crushing the ammonium nitrate prills. Most of the premixed ANFO commercially sold in the U.S.A., however, does not become cap sensitive by crushing the prills. ANFO obtained by first crushing prilled ammonium nitrate commercially bought in the U.S.A. and then mixing it with fuel oil will also, in general, not be cap sensitive. If either the ANFO or the ammonium nitrate used to mix it were obtained from certain areas outside the U.S.A. , crushing of the prills may render it cap sensitive. In all these cases of “cap sensitivity”, however, a high powered detonator (e.g. one containing 1 g base charge) is still needed, and also a certain amount of special information is required, whereas modern propellants as well as all types of black powder can be initiated by a heat source only, like match heads, squibs, or even only an electrically heated wire or a spark.

The initiation requirements for various configurations are summarized in Table 1 below. It should be noted that this table is intended to give a general overview and that it cannot present all limitations, exemptions, or special circunwtances.

Table 1

MATERIAL	REQUIRED FOR INITIATION	
	CONFINED	UNCONFINED
Small amounts of commercial ANFO (-- 2 kg.)	Booster charge of 50-500 g high explosive	(NO Reaction)
Large amounts of commercial ANFO (> 50 kg)	Booster charge of 50-500 g high explosive	Booster charge of 50-500 g high explosive
Sensitized ANFO or special mix blasting agent	Detonator with at least lg base charge or 6" prima cord (50 grainift.) + small detonator like below	Detonator with at least 1 g base charge or 6" prima cord (50 grain\ft.) + small detonator like below
Military explosive like Comp. B or Comp. C-4	Small detonator with about .25 g base charge	Small detonator with about . 25 g base charge
Modern propellant or black powder	Heat source like matchhead, squib, hot wire, or spark	(No explosion; only violent burning possible)

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To compare the damage producing capability of destructive explosive devices, one has to consider air blast, fragmentation, and potential incendiary effects. Assuming the initiation problems can be resolved for an explosive device containing only a few kg of a blasting agent similar to ANFO, then the air blast caused by this device could do approximately as much air blast damage as a device with the same weight of TNT (see Figure 1). The density difference between ANFO and TNT (approximately **0.8 vs. 1.6)** would require a larger confinement volume for a device containing ANFO.

Comparing fragmentation of a device loaded with TNT versus one loaded with a blasting agent similar to ANFO, the latter would produce a smaller number of fragments larger in size and with a somewhat lower velocity than the TNT device. The total damage producing capability of the fragments of the ANFO device would probably come fairly close to that of the TNT device. Neither one of the two device types would produce any significant incendiary effect.

The damage producing capability of propellant or black powder loaded devices will generally be significantly smaller than that of devices loaded with an ANFO-like blasting agent due to the following reasons:

(a) The rate Of energy release iS much higher in high explosives, including blasting agents like ANFO, than in propellants including black powder. Expressed, e.g. in Megawatts, a 5 cm diameter device loaded with ANFO delivers energy at a rate of about 10,000 MW; a gun cartridge of the same diameter delivers energy at a rate of about 500 MW.

(b) The rate of detonation of high explosives, including blasting agents like ANFO, is only weakly depending on ambient conditions whereas the propellant burn rate strongly depends on the ambient pressure. Propellants including black powder which are initiated in a metallic shell will frequently violently rupture the shell at a time when only a fraction of the propellant energy has been released, producing

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only very few medium velocity fragments and only a moderate pressure wave . The burn rate of the still remaining mass of propellant will at the time of the shell rupture drop to a very low rate imposing no other danger than a fire hazard. A high explosive or blasting agent detonated in a metallic confinement like a bomb shell will always produce a number of high velocity fragments and a strong air blast.

To summarize, it can generally be expected that the damage producing capability of an explosive device loaded with an ANFO-like blasting agent, if it is properly initiated, is somewhat smaller than that of a device of equal weight loaded with TNT, but significantly larger than that of a device of equal weight loaded with black powder or modern propellants.

Very truly yours,

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Roland R. Franzen
Senior Staff Engineer

Attachment: Figure 1

Figure 1.—Airblast Pressures From TNT and Field Mixed AN/FO Fired on Ground

This figure was copied from: L. D. Sadwin, J. F. Pittman, Airblast Characteristics of ANFO. U.S. Naval Ordnance Laboratory, White Oak, MD April 1969.