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LEAD AZIDES FOR USE IN DETONATORS

by

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OBJECT

To determine the physical, chemical, and explosive properties of various types of lead azide which might replace dextrinated lead azide in Ordnance Corps ammunition.

SUMMARY

During the development of a short detonator (M47) for use in 20 mm ammunition it became evident that smaller fuzes were made, more efficient explosives for use in initiators would be needed. To meet such a need several different types of lead azide were investigated as possible replacements for the standard dextrinated lead azide covered by Military Specification MIL-L-3055. The types of lead azides investigated include dextrinated, RD-1333, polyvinyl alcohol (PVA), British Service, colloidal, and dextrinated colloidal.

A minimum of 25 mg RD-1333 lead azide or 30 mg PVA lead azide was required to initiate RDX in the M47 detonator as compared with 90 mg for dextrinated lead azide. Neither RD-1333 nor PVA was hygroscopic, but dextrinated lead azide picked up over .5% moisture in 35 minutes at 82%-92% relative humidity. RD-1333, PVA, British Service, colloidal, and dextrinated colloidal lead azide had impact sensitivities of 5, 4-5, 2, 2, and 3 inches, respectively, using the 2-kg weight, as compared with 4-6 inches for dextrinated lead azide.

CONCLUSIONS

1. RD-1333 lead azide and PVA lead azide are superior to dextrinated lead azide in both chemical and functioning characteristics.
2. British Service, colloidal, and dextrinated colloidal lead azide are inferior to RD-1333 or PVA lead azide for use in the intermediate charge of detonators.

RECOMMENDATIONS

1. RD-1333 lead azide should be used in all new detonator design work and PVA lead azide should be specified as an alternate material.
2. Work to investigate other new types of lead azide to achieve further improvement should be continued.

INTRODUCTION

1. Lead azide was first prepared and identified in 1891 by Curtis. The first attempt to use lead azide practically in the explosives industry was made by F. Myronius in France in February 1907. He secured French Patent 384,792 for the use of lead azide in detonators. The general application of lead azide to military ammunition, however, was retarded by hazards of manufacture and its erratic sensitivity to impact. Indeed, the history of the manufacture of lead azide is marred by fatal explosions. It was believed that these explosions were caused by the fracture of crystals which were too large or too easily fractured. During that period the idea was implanted that large crystals of lead azide were extremely sensitive and that the beta form was both extremely sensitive and unstable.

2. To overcome this problem of the formation of undesirable crystals, various materials such as glue, dextrin, and other colloids were used in the precipitating solution. These materials prevent the formation of distinct crystals and also limit the crystal size of the lead azide. Around 1932, E. I. du Pont de Nemours and Co. began to manufacture a modified lead azide using dextrin in the precipitating solution. The material was and still is referred to as dextrinated lead azide. Shortly thereafter the Ordnance Corps adopted the use of dextrinated lead azide in detonators as a replacement for mercury fulminate. The new lead azide was more stable and less sensitive than mercury fulminate.

3. Until around 1951 dextrinated lead azide was used in military ammunition with satisfactory results. During the development of the M47 detonator, however, it became evident that more powerful and efficient initiating explosives were needed for use in detonators. The M47 at the time of its development was the smallest stab-type detonator in general use by the Army Ordnance Corps. The difficulty was that there just did not seem to be enough room in the detonator to contain the explosives needed to achieve what was required of the detonator. Consequently a program was started to evaluate different types of lead azide having greater initiating power than dextrinated lead azide.

4. Six types of lead azide were subjected to various tests to determine their physical and functioning characteristics. The different types were:

a. Dextrinated lead azide, the first standard United States service type, made by precipitation in the presence of dextrin.

b. RD-1333 lead azide, an experimental British type, developed in an attempt to replace British Service lead azide. It is made by precipitation in the presence of a special agent (Ref 1).

c. PVA lead azide, polyvinyl alcohol lead azide, developed by the Olin-Mathieson Chemical Corporation. It is made by precipitation in the presence of polyvinyl alcohol (Patent No. 2,421,778).

d. British Service lead azide, the standard United Kingdom service lead azide. It is made by using lead carbonate as a nucleating agent.

e. Colloidal lead azide, unadulterated lead azide of very small (3-4 micron) particle size. It is made by careful control of the precipitating solution, temperature, concentration, pH, and other process parameters.

f. Dextrinated colloidal lead azide, made experimentally by the Olin-Mathieson Chemical Corporation. It is made in essentially the same way as dextrinated lead azide except that process controls are regulated to give an end product of a very small (1-2 micron) particle size.

RESULTS

Physical and Chemical Characteristics

5. Composition, stability, and sensitivity characteristics of the various types of lead azide investigated are summarized in Table 1 (p 4). A curve of the hygroscopicity of dextrinated lead azide is given in Figure 1 (p 26). The nondextrinated forms are essentially nonhygroscopic. Pressure-density curves are given in Figure 2 (p 27). Particle size characteristics are summarized in Table 2. Photomicrographs showing the different types of lead azide investigated are shown in Figures 3 to 8 (pp 28 to 33).

Functioning Characteristics

6. Tests were conducted to determine the effect of varying quantities of moisture in dextrinated lead azide when used as the intermediate charge of the M47 detonator. In these tests, detonators containing 0.8% or more moisture in the lead azide charge functioned low order. Detailed results are contained in Table 7 (p 19).

TABLE 1

Laboratory Test Results for Lead Azide

Test	Type Lead Azide			
	Destriated	RD-1333	PVA	British Service Colloidal
Lead azide, %	92.8	98.7	96.0	98.1
Total lead, %	69.3	71.06	71.6	71.5
Explosion temperature (5-sec value), °C	340	345	340	350
Vacuum stability:				
100°C, ml gas/g/40 hr	0.23-0.41	-	0.16-0.23	-
120°C, ml gas/g/40 hr	0.46	0.43	0.44	-
100°C Heat test:				
Loss in sample wt in 8 hr, %	-	0.30	0.12	0.11
Loss in sample wt in 48 hr, %	0.34	0.30	0.13	0.08
Loss in sample wt in 96 hr, %	0.39	0.30	-	-
Explosion in 100 hr	none	none	none	none
Impact sensitivity:				
PA App, 2-kg wt, in.	4-6	5	4-5	2
Charge wt, mg	28	23	30	37
BM App, 2-kg wt, cm	10-28	15	13-16	30
PA App, 500-g wt, in.	12	15	18	-
Charge wt, mg	28	21	31	-
BM App, 500-g wt, cm	100+	100+	100+	-

TABLE 2
Particle Size of Lead Azide

Type Lead Azide	Geometric Mean, microns	Geometric Standard Deviation, microns
Dextrinated	24.5	-
RD-1333	34.5	1.97
PVA ¹	19.0	2.7
British Service	55	-
Colloidal	3.4	-
Colloidal dextrinated	1.74	-

¹ Average particle length, 22 microns; geometric standard deviation, 3.0 microns.
Average particle width, 8.6 microns; geometric standard deviation, 2.1 microns.

7. Modified M47 detonators were loaded using different charge weights of several of the various lead azides under investigation. Results showing the minimum charge weight of lead azide required to initiate the RDX base charge in the detonator are summarized in Table 3. Detailed results of these tests are contained in Table 8 (p 20).

TABLE 3
Minimum Charge Weight of Lead Azide to Initiate RDX in the M47 Detonator

Type Lead Azide	Wt Lead Azide, mg
Dextrinated	90
RD-1333	25
PVA	30
British Service	25

8. M47 and modified M47 detonators containing either PVA or RD-1333 lead azide were subjected to periodic functioning tests after storage at 71°C. All of the detonators withstood these adverse storage tests without

substantial detriment to their functioning capabilities. Results are summarized in Table 4 below and detailed in Tables 9 to 11 (pp 22 to 23).

TABLE 4

**Results of Functioning Tests of M47 and Modified M47 Detonators
After Long-Term Storage at 71°C¹**

Type Lead Azide, Intermediate Charge	Avg Diam of Hole in Lead Disc, in., Before Storage	Storage Time, months	Avg Diam of Hole in Lead Disc, in., After Storage
Dextrinated	0.213	17	0.230
RD-1333	0.281	12	0.248
PVA	0.281	13	0.246

¹Tests conducted in accordance with paragraph 4.6 of Specification PA-PD-202 (Rev 1) dated 30 Sep 1952 with Amendment 1 dated 27 Jan 1953.

9. A group of modified M47 detonators containing 15/70/60 mg NOL No. 130 primer mixture/PVA lead azide/RDX was loaded. Each charge was consolidated at approximately 15,000 psi. These detonators were subjected to functioning tests periodically during two JAN temperature and humidity cycles (Ref 2). One-hundred detonators were removed every seven days and tested. The last group, removed after four weeks of cycling, caused perforation of the lead disc. The average hole diameter was 0.254 inch. Detailed results of the cycling tests are listed in Table 12 (p 24).

10. Five groups of M47 type detonators were loaded in accordance with Figure 9 (p 34) except for the variations listed in Table 5 (p 7). These detonators were subjected to standard acceptance tests in accordance with Reference 3. Three-hundred detonators of each group were tested. All groups passed this test, producing holes in the lead discs not less than 0.156 inch diameter. Although one failure occurred in group 5, 603 detonators from this group functioned satisfactorily when retested.

11. Samples of 25 detonators from each of the five groups loaded as described in paragraph 10 were subjected to booster initiation and waterproofness tests as specified in Reference 3. All groups fired satisfactorily in both tests.

TABLE 5**Explosive Charges of Modified M47 Detonators**

Group	NOL No. 130	Lead Azide		RDX mg
	Primer Mix, mg	Type	mg	
1	14	Dextrinated	103	34
2	23	Dextrinated	86	41
3	26	PVA	95	36.5
4	34	PVA	90	37
5	29	PVA	76	40

12. One-hundred detonators from each of the five groups loaded as described in paragraph 10 were assembled into M505 fuzes, modified for detonator safety tests. The modified fuzes were assembled to M97A1 HEI 20 mm shell and fired statically with the detonator in the out-of-line position. The following results were obtained.

TABLE 6**Detonator Safety Tests**

Group	No. of Detonators Tested	No. of Boosters Fired
1	95	32
2	100	34
3	100	17
4	100	48
5	100	28

13. M47-type detonators of groups 1, 3, and 5 loaded as described in paragraph 10 were assembled into M505 fuzes. The fuzes were in turn assembled to M97A1 HEI 20 mm shell, which were then subjected to ballistic firing tests. One-hundred rounds from each group were fired at ambient temperature, at 165°F, and at -65°F, using the standard propellant charge. Approximately 100 rounds of each group were fired at ambient temperature at 112% service chamber pressure. All rounds were fired against 0.040-inch 24 ST aluminum targets placed normal to the line of fire, 325 feet

from the muzzle of the gun. All rounds functioned properly. No dud or premature was observed. Detailed results of these tests are contained in Table 13 (p 25).

DISCUSSION OF RESULTS

14. It will be apparent to the reader in studying the results that certain tests were conducted on some types of lead azide and not on others. It should be explained that this investigation was conducted over a span of several years, with each type lead azide more or less handled as a separate study. The variation in tests conducted on the different types of lead azide was, for the most part, a result of the emphasis placed on the work at the time it was being done. For example, detonator safety tests and ballistic firing tests were conducted only on PVA lead azide. At the time PVA lead azide was being investigated, there was a need to replace dextrinated lead azide in the M47 detonator with a more powerful explosive. Since the use of a more powerful lead azide would possibly make the detonator more powerful, detonator safety tests were indicated. Also, since this was to be the first practical use in the Ordnance Corps of PVA lead azide, ballistic firing tests of rounds containing detonators loaded with PVA lead azide were considered necessary.

15. Another reason for the difference in the tests was that early work on some types showed them to be impractical as a substitute for dextrinated lead azide. Since finding such a substitute was the prime purpose of this investigation, extensive tests of these types were not conducted.

16. Colloidal lead azide is not suited for uses requiring good flow characteristics. It is ideal as a spot charge or priming charge in electric initiators, however, primarily because of its very fine particle size (Ref 4). Before colloidal lead azide was available, regular lead azide (dextrinated) had to be milled to obtain a material suitable for this application. The use of colloidal lead azide now eliminates the milling operation of dextrinated lead azide which, even under carefully controlled conditions, is hazardous.

17. Dextrinated colloidal lead azide was investigated as a substitute for colloidal lead azide primarily in the hope of finding a material which would be suitable for use next to the bridge in electric initiators but which would be less sensitive to shock than colloidal lead azide. Results of this work indicated that its sensitivity was not substantially less than colloidal lead azide and the investigation was dropped.

18. The results reported in Table 1 (p 4) represent a series of laboratory tests which show purity, stability, and impact sensitivity characteristics of the various lead azides investigated. The results of tests for purity (% lead azide and % total lead) indicate that each type has a characteristic lead azide content. This is considered to be an inherent characteristic of the material because of the adulterants used during manufacture, as well as the controls used in the process itself, such as temperature and rate of agitation. The differences in purity, however, do not seem to be marked enough to provide an adequate means of differentiating between types. Neither is the lead azide content a good indication of ability to initiate another explosive, as will be shown later.

19. The lead azide content is determined by measuring the nitrogen content of the sample and calculating % lead azide. The % lead in a sample on this basis is always less than that given by a total lead analysis. A sample calculation showing this is outlined below:

Molecular weight of PbN_6	291.258
Molecular weight of Pb	207.21
% Pb in PbN_6	$\frac{207.21}{291.258} \times 100 = 71.08$
% PbN_6 , dextrinated lead azide (Table 1)	92.8
% Pb in sample based on lead azide	$71.08 \times 0.928 = 65.96$
% Total lead in sample based on analysis for Lead (Table 1)	69.3
% Excess lead in sample in addition to that calculated from PbN_6	$69.3 - 65.96 = 3.4$

It is believed that the impurities in the dextrinated, RD-1333, PVA, and dextrinated colloidal lead azides, which are manufactured using organic additives, are lead organic complexes and lead hydroxide.

20. Some work on impurities in British Service lead azide is described in Reference 5. Here it is stated that lead carbonate, which is used as a nucleating agent during manufacture, is incorporated in the molecule and that the surface of crystals of British Service lead azide is pure lead azide.

21. Vacuum stability tests and 100°C heat tests indicate that the types of lead azide investigated as possible replacements for dextrinated lead

azide give off no more gas and lose no more weight on heating than dextrinated lead azide. Based on the data in Table 1 (p 4), all types investigated are considered stable.

22. One of the major problems connected with the use of primary explosives such as lead azide is that they are relatively sensitive to initiation by mechanical energy. The Picatinny Arsenal impact sensitivity test gives a relative indication of sensitivity to impact and is used as a guide in establishing handling procedures. These procedures have been well established for dextrinated lead azide (impact sensitivity on PA machine with a 2-kg wt is 4-6 in.) and for more sensitive explosives such as colloidal lead azide (impact sensitivity on PA machine with a 2 kg-wt is 2 in.). It is certainly not desirable, however, to use explosives which are this sensitive unless necessary. This being the case, a dim view was taken of substituting for dextrinated lead azide a more sensitive material. British Service lead azide, colloidal lead azide, and dextrinated colloidal lead azide all fell into this category. The impact sensitivity of PVA lead azide and RD-1333 azide compared favorably with that of dextrinated lead azide.

23. Results shown in Figure 1 (p 26) illustrate the hygroscopic nature of dextrinated lead azide. More extensive tests demonstrating this hygroscopicity are reported in Reference 6. It is evident that dextrinated lead azide used on the loading lines could have a higher moisture content than the 1.5% maximum permitted by Reference 3. Considerable time could elapse between the time that the "dried" lead azide is removed from the dry house until it is used on the loading line. It has to be screened and subdivided into containers, which are placed in boxes equipped with loose fitting lids. The boxes are stored in rest houses for an indeterminate length of time. Periodically, these boxes are transferred to chimney-type barricades prior to use on the loading lines. Finally, the containers are removed from the box and placed in the loading barricade, where the azide is used in loading ammunition. While the material is in these barricades, atmospheric conditions more often than not are favorable for the dextrinated lead azide to pick up moisture. In fact, the chimney barricade seems to be an ideal arrangement for this to take place.

24. Having demonstrated the hygroscopic nature of dextrinated lead azide and realizing that it can contain moisture when loaded, the effect of moisture on its functioning was considered. It is logical to assume that some of this moisture would have to be volatilized before the lead azide could be raised to a temperature high enough to be initiated by flame. Therefore, it

is considered that the higher the moisture content, the harder it will be to initiate the lead azide, especially by heat transfer. Because of the moisture present and the slower resulting initiation, it is believed that the output of lead azide is reduced considerably. This decrease in output might be the result of a substantial decrease in the stable detonation rate or the inability of the lead azide to attain its stable rate of detonation in a limited column length.

25. The latter assumption is considered to be the more valid of the two, since the difference in the functioning of dry and moist lead azide is most pronounced when the quantities and column lengths are small. It has been tentatively established that a column length of approximately 0.1 inch dry dextrinated lead azide is required for high-order initiation of RDX if the diameters of the columns and the consolidation pressures are similar to those used in loading Ordnance Corps detonators. Since most detonators are designed with a considerably longer lead azide column, the effect of moisture in lead azide is not generally noted. In short detonators such as the M47, however, the effect of moisture is very noticeable (see Table 7, p 19). This points up the inability of the lead azide to attain its stable detonation rate in short columns in the presence of appreciable quantities of moisture.

26. Aside from impairing the functioning of lead azide, moisture in a detonator has other detrimental effects. When moisture is present in the lead azide charge, it promotes the hydrolysis of the lead azide with the formation of hydrazoic acid. This acid can react with copper or copper-bearing alloys to form cupric azide (Refs 7 and 8).

27. When hydrazoic acid reacts with copper or cupric oxide, the cupric azide ($\text{Cu}(\text{N}_3)_2$) is formed as very dark brown needles with a reddish glow or as a moss-green granular material (Ref 5). Anhydrous cupric azides are said to be very sensitive, especially to friction. It is stated in Reference 9 that "copper azide is of such sensitiveness to friction that already a stroke with a feather of a hen would be sufficient to detonate the salt "

28. In view of the above discussion the possibility that accidents could be caused by the formation and initiation of sensitive copper azide is realistic. Therefore, one of three things can be done to prevent the formation of the undesirable azide. One is to substitute another explosive for lead azide, the second is to render the gilding metal cup compatible by coating, and the third to exclude the use of copper or copper-bearing alloys.

29. The substitution of another explosive for lead azide is unlikely in the near future. Because of the extreme stability, high density, and output of lead azide, it is believed that it will be some time before any explosive is developed which can take its place. However, improvements can be made by using types other than the standard dextrinated lead azide, such as PVA lead azide and RD-1333 lead azide, which are relatively nonhygroscopic. This will decrease the likelihood of moisture getting inside the detonator cup.

30. With regard to coating of copper parts, no matter what type of coating material is used, there is always the possibility of its being scraped off and leaving the copper surface exposed. The British at present use tin-coated copper cups for containing lead azide (Ref 10).

31. The substitution of another material for copper-bearing alloys or copper is feasible and some work has been done in this direction. The Navy has recognized the problem of compatibility and uses only aluminum and stainless steel as the detonator cup material. The Ordnance Corps prefers stainless steel as a detonator cup material, however gilding metal and aluminum are also used. Both stainless steel and gilding metal provide better confinement than aluminum.

32. In studying new types of lead azide, a great deal of care was taken regarding characterization of crystal size. It has always been generally accepted that a few of the accidental explosions which have occurred with lead azide during its history were caused by the fracture of crystals which were too large or too easily fractured. Much has been written on this subject but there is little supporting data in the literature. Garner and Gomm (Ref 11) found that lead azide exists in two distinct crystalline forms: the ordinary alpha form and a less common beta form. Subsequent work (Ref 12) by Miles suggests that accidental explosions might be attributed to the growing of the beta variety and are not necessarily caused by the so-called "extreme" sensitivity of abnormally long crystals which may be present. On the subject of long crystals, Miles says "The idea that large crystals of such explosive substances as lead azide are always excessively sensitive to shock or friction has been widely received, but in view of these facts seems to have little foundation."

33. Recent work by Armour Research Foundation (Ref 13) has shown that beta lead azide readily changes to the alpha form in the presence of alpha lead azide and water. It was also shown that it takes a very carefully controlled and exacting procedure to manufacture beta lead azide.

Consequently, unless it is the specific intention to manufacture beta lead azide, the alpha lead azide is produced. If any beta lead azide is produced in the preliminary stages when making alpha lead azide, and if it should be carried to the end product, it would be rapidly transformed to the alpha form when the materials are stored under water.

34. It is believed that the sensitivity of lead azide is due at least in part to internal stresses formed in the crystal which are an inherent result of the manufacturing process. Consequently both large and small crystals could be stressed, making them extremely sensitive to impact. In support of this theory it may be noted that colloidal lead azide, which has a very small crystal size, is a great deal more sensitive to impact than PVA or RD-1333 lead azide, which have a much larger crystal size. Further confirmation that crystal size is not a controlling influence on impact sensitivity may be found in Reference 23.

35. The preceding discussion is related to this report in that certain groups dealing with PVA lead azide have expressed much concern because its crystal size is larger than that of the conventional dextrinated lead azide. In addition, the shape of its crystals, rather long and narrow, indicates to some that beta lead azide may be present. Based upon the discussion in paragraphs 32-34, however, it is considered that PVA lead azide and RD-1333 lead azide if made properly are acceptable and can be handled safely using the same precautions observed when handling the conventional dextrinated lead azide.

36. The functioning characteristics of lead azide used as the intermediate charge in the M47 type detonator indicate that PVA and RD-1333 lead azides are about 2.5 times more efficient than dextrinated lead azide when used in small quantities (see Table 8, p 20). The difference between the output of the materials may be due to two factors. First, dextrinated lead azide contains less lead azide than the other types investigated. This is considered to be a minor point. More important, however, it is believed that types investigated (including PVA and RD-1333) other than dextrinated lead azide build up to a stable detonation rate in a much shorter column length than dextrinated lead azide. It is believed that this is due to three factors: One, the other types of lead azide investigated may be more readily initiated; two, because of their crystalline structure they have fewer voids to traverse; and three, their pressure-density relationship is such that they have a higher pressed density, thus creating a self-confinement which reduces the loss of energy to the outside.

37. The increased output of PVA and RD-1333 lead azide seems to be ideally suited to small detonators where available charge space is limited. Use of PVA or RD-1333 lead azide in small detonators instead of dextrinated lead azide will result in increased amounts of base charge, which would substantially increase the output of the detonator itself.

38. Tables 9, 10, and 11 (pp 22 and 23) show the results of functioning tests conducted periodically on M47 type detonators containing dextrinated, PVA, and RD-1333 lead azide as the intermediate charge during storage at 71°C. Several duds were encountered over the storage period. These duds were due to failure of the primer mix to be initiated and not to any deficiency of the lead azide charge. The fact that no low-order functioning of the detonators was observed throughout the storage program indicates that these materials when loaded in detonators are stable for long periods of storage.

39. From the results obtained, it is obvious that two types, PVA and RD-1333, stand out as being generally superior to dextrinated lead azide. The other types investigated, British Service, colloidal, and dextrinated colloidal, while superior to dextrinated lead azide in some respects, such as output and hygroscopicity, have certain disadvantages such as flowability or sensitivity to shock. It is concluded that detonator design can be substantially improved by using PVA or RD-1333 lead azide instead of dextrinated lead azide.

40. RD-1333 lead azide has one advantage over PVA lead azide which has not been discussed yet. This is the fact that RD-1333 lead azide is a nonproprietary material. PVA lead azide is a patented product (Patent No. 2,421,778 dated 10 June 1947) currently being manufactured by the holder of the patent, Olin Mathieson Chemical Corporation, East Alton, Illinois. On this basis, PVA lead azide may be considered second choice to RD-1333 lead azide.

41. Work to develop improved types of lead azide is continuing. Currently being considered as an improvement over RD-1333 lead azide is a type known as RD-1343 lead azide (Ref 5). It is expected that little will be achieved in obtaining a type lead azide having greater initiating ability than RD-1333 lead azide. It is expected, however, that improvements such as higher bulk density which will enhance its loading properties can be achieved. RD-1343 lead azide will be the subject of a technical report in the future.

EXPERIMENTAL PROCEDURE

42. The materials used in the work covered by this report include:

Material	Specification	Dated
Lead azide (dextrinated)	MIL-L-3055 Amend 1	24 March 1952
Polyvinyl alcohol lead azide	Commercial	
British Service lead azide	IG 237	5 Jan 1942
RD-1333 lead azide	Commercial	
Colloidal lead azide	Commercial	
Dextrinated colloidal lead azide	Commercial	
Basic lead styphnate, 90% min through 325 mesh	Commercial	
Tetracene, 50% min through 325 mesh	Commercial	
Antimony sulfide, Grade 1 Class a, b, or c	JAN-A-159	31 March 1948
Barium nitrate, Class a, 99% min through 70 mesh, 99% min on 140 mesh	JAN-B-162	28 August 1946
Gilding metal (95/5 brass); sheet and strip	JAN-G-439	31 December 1949
RDX, Type B, Class C	PA-PD-416	13 May 1954

43. The color, form, lead azide content, total lead, acidity, and solubility tests were conducted in accordance with the methods outlined in Reference 14. Explosion temperature, vacuum stability, and impact sensitivity tests were conducted in accordance with the methods outlined in Reference 15.

44. The pressure-density relationships of dextrinated lead azide and PVA lead azide were determined in accordance with the procedure specified in Reference 16, with the following modifications:

a. A No. 8 blasting cap shell was inserted into an aluminum cup (length, 2.00 ± 0.05 inches; internal diameter, 0.248 ± 0.005 inch; wall thickness, 0.025 ± 0.001 inch) supported in a 5-ml graduated cylinder which had been cut down to a 3-ml capacity. This was weighed on a balance, using as a tare weight an empty cap, and another aluminum cup and graduate

of similar dimensions. The shell was then filled with mercury and the excess mercury carefully removed with a glass slide. The mercury-filled shell was weighed as before and the weight of mercury in the shell determined by difference.

b. After consolidating the increments at the pressures stated and weighing the sample contained in the blasting cap shell, mercury was added to fill the remainder of the space in the shell. Again the excess mercury was removed and the weight of the shell containing the sample and mercury determined.

45. Hygroscopicity tests were conducted as specified in Reference 17.

46. The detonators used in this report were loaded in the manner standard at Picatinny Arsenal. References 18 and 19 give details of the processing of the explosives and explosive mixtures and the loading of the M47 detonators. These are typical of the processing of explosives and loading of detonators used in the work described in this report.

47. The functioning, waterproofness, and booster initiation tests were conducted by the methods outlined in Reference 3. The method of conducting detonator safety tests and the ballistic firing tests is given in Reference 20. Particle size measurements of PVA lead azide were obtained using the methods described in Reference 21. The method of loading the 5 groups of detonators (paragraph 11) is contained in Reference 22.

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TABLE 7**Functioning of M47 Detonators Containing Dextrinated Lead Azide
Having Known Amount of Moisture**

Moisture, %	No. Tested	No. Fired		Diameter of Hole in Lead Disc, in. ^c		
		High Order ^a	Low Order ^b	Avg	Min	Max
0.5	35	35	0	.236	.210	.267
0.6	35	35	0	.235	.221	.254
0.8	35	35	2	.227	.176	.245
0.9	35	30	5	.217	.151	.244

After Two Weeks Storage at Ambient Temperature

0.5	35	35	0	0.233	0.210	0.255
0.6	35	35	0	0.233	0.193	0.261
0.8	35	35	2	0.232	0.168	0.258
0.9	35	21	14	0.225	0.189	0.248

^aDetonator perforated lead disc.^bDetonator failed to perforate lead disc.^cLow order are not included in calculation of hole sizes.

TABLE 8

Results of Functioning Tests of Modified M47 Detonators^a

No. Tested	Detonated		No. Fired		Diameter of Hole in Lead Disc, in. ^d		
	Lead Azide, mg	RDX, mg	High Order ^b	Low Order ^c	Avg	Max	Min
45	110	34	45	0	0.212	0.232	0.177
45	100	40	45	0	0.218	0.244	0.170
45	90	44	45	0	0.194	0.228	0.081
45	85	46	44	1	0.219	0.251	0.159
45	80	49	28	17	0.149	0.214	0.075
45	75	51	2	43	0.163	0.245	0.081
45	70	53	0	45	-----	-----	-----

RD-1333
Lead Azide,
mg

49	70	55	49	0	0.271	0.295	0.247
50	65	60	50	0	0.276	0.303	0.249
50	55	63	50	0	0.282	0.306	0.258
50	50	66	50	0	0.286	0.319	0.262
50	45	69	50	0	0.273	0.306	0.240
50	40	72	50	0	0.288	0.318	0.258
50	35	75	50	0	0.290	0.313	0.253
50	30	78	50	0	0.266	0.285	0.228
50	25	80	50	0	0.239	0.277	0.192
50	20	82	44	6	0.213	0.252	0.158

^a Detonators contained 13 mg NOL 130 primer mix in addition to charges shown in table. Tests conducted in accordance with paragraph 4.6 of Spec PA-PD-202 (Rev 1) dated 30 Sep 1952 with Amendment 1, dated 27 Jan 1953.

^b High order; detonator caused perforation of lead disc.

^c Low order; detonator failed to cause perforation of lead disc.

^d Low orders are not included in calculation of hole sizes.

TABLE 8 (Cont)

No. Tested	PVA		No. Fired		Diameter of Hole in Lead Disc, in.		
	Lead Azide, mg	RDX, mg	High Order	Low Order	Avg	Max	Min
45	70	60	45	0	0.260	0.308	0.230
45	60	62	45	0	0.267	0.291	0.230
45	55	64	45	0	0.264	0.298	0.206
45	50	67	45	0	0.263	0.303	0.206
45	45	70	45	0	0.252	0.290	0.192
45	40	72	45	0	0.269	0.302	0.231
45	35	74	44	1	0.224	0.275	0.181
45	30	76	45	0	0.236	0.276	0.197

British
Service
Lead Azide,
mg

45	70	61	45	0	0.276	0.300	0.225
45	60	64	45	0	0.273	0.295	0.232
45	55	66	45	0	0.280	0.314	0.238
45	50	68	45	0	0.275	0.296	0.241
45	45	71	45	0	0.269	0.296	0.218
45	40	73	45	0	0.267	0.288	0.224
45	35	74	45	0	0.260	0.294	0.216
45	30	76	45	0	0.259	0.306	0.229
45	25	77	45	0	0.229	0.277	0.206
45	20	79	21	24	0.191	0.263	0.115

TABLE 9

Results of Functioning Tests of M47 Detonators After
Long-Term Storage at 71°C^a

Storage Time, months	No. Tested	Diameter of Hole in Lead Disc, in.		
		Avg	Max	Min
0	230	0.213	0.240	0.174
1	50	0.215	0.243	0.179
2	50	0.221	0.249	0.189
3	50	0.221	0.247	0.192
4	50	0.228	0.251	0.200
5	50	0.215	0.242	0.178
6	50	0.225	0.275	0.190
7	50	0.213	0.241	0.189
8	50	0.224	0.249	0.199
9	50	0.220	0.252	0.156
10	50	0.228	0.261	0.190
12	50	0.230	0.284	0.210
13	100	0.223	0.266	0.200
14	50	0.231	0.259	0.207
15	50	0.229	0.263	0.220
16	50	0.217	0.245	0.199
17	50	0.230	0.274	0.209

^a Detonators contained: 15-5 mg NOL 130 primer mix
110-10 mg dextrinated lead azide
Approx 34 mg RDX

All detonators tested in accordance with paragraph 4.6 of Purchase Description PA-
PD-202.)

TABLE 10

**Results of Functioning Tests of Modified M47 Detonators
Containing RD-1333 Lead Azide After Long-Term Storage at 71°C^a**

Storage Time, months	No. Tested	Diameter of Hole in Lead Disc, in.		
		Avg	Max	Min
0	100	0.281	0.311	0.251
1	75	0.275	0.290	0.250
2	100	0.263	0.288	0.224
3	100	0.267	0.292	0.240
4	100	0.283	0.298	0.245
6	100	0.274	0.293	0.239
8	100	0.266	0.296	0.234
12	100	0.248	0.280	0.196

^aDetonators contained 13/40/72 mg NOL 130 primer mixture/RD-1333 lead azide/RDX. Tests were conducted in accordance with PA-PD-202.

TABLE 11

**Results of Functioning Tests of Modified M47 Detonators
Containing PVA Lead Azide After Long-Term Storage at 71°C^a**

Storage Time months	No. Tested	Diameter of Hole in Lead Disc, in.		
		Avg	Max	Min
0	100	0.281	0.308	0.252
1	99	0.261	0.287	0.213
2	100	0.256	0.278	0.238
3	100	0.254	0.269	0.198
5	100	0.245	0.278	0.196
7	100	0.265	0.282	0.240
9	100	0.231	0.248	0.219
11	100	0.233	0.258	0.206
13	100	0.246	0.261	0.232

^aDetonators contained 15/70/60 mg NOL 130 primer mix/PVA lead azide/RDX. Tests conducted in accordance with paragraph 4.6 of Purchase Description PA-PD-202.

TABLE 12

Functioning Tests of Modified M47 Detonators
Containing PVA Lead Azide After JAN Cycling^a

Storage Period, wk	No. Fired			Diameter of Hole in Lead Disc, in. ^a			
	High Order ^b	Low Order ^c	Dud ^d	Avg	Max	Min	Std Dev
0	100	0	0	0.281	0.308	0.252	0.013
1	99	0	1	0.262	0.295	0.234	0.017
2	100	0	0	0.266	0.292	0.215	0.013
3	100	0	0	0.248	0.281	0.216	0.016
4	100	0	0	0.254	0.288	0.232	0.015

Overall average 0.262

^a Detonators contained 15/70/60 mg NOL 130 primer mix/PVA lead azide/RDX. Tests conducted in accordance with paragraph 4.6 of Purchase Description PA-PD-202.

^b High order; detonator caused perforation of lead disc.

^c Low order; detonator failed to cause perforation of lead disc.

^d Detonator was not initiated.

^e Low orders and duds not included in calculations.

TABLE 13

Ballistic Firing Tests

Group	Temperature	Fired	No. Rounds	
			Hitting Target	Functioning
1	ambient	100	97	97
2	-65° F	100	94	94
2	165° F	89	84	84
2	ambient	100 ^a	98	98
3	ambient	100	94	94
3	-65° F	100	97	97
3	165° F	79	75	75
3	ambient	100 ^a	96	96
5	ambient	100	100	100
5	-65° F	100	97	97
5	165° F	80	77	77
5	ambient	100 ^a	92	92

^a Fired at 112% service pressure

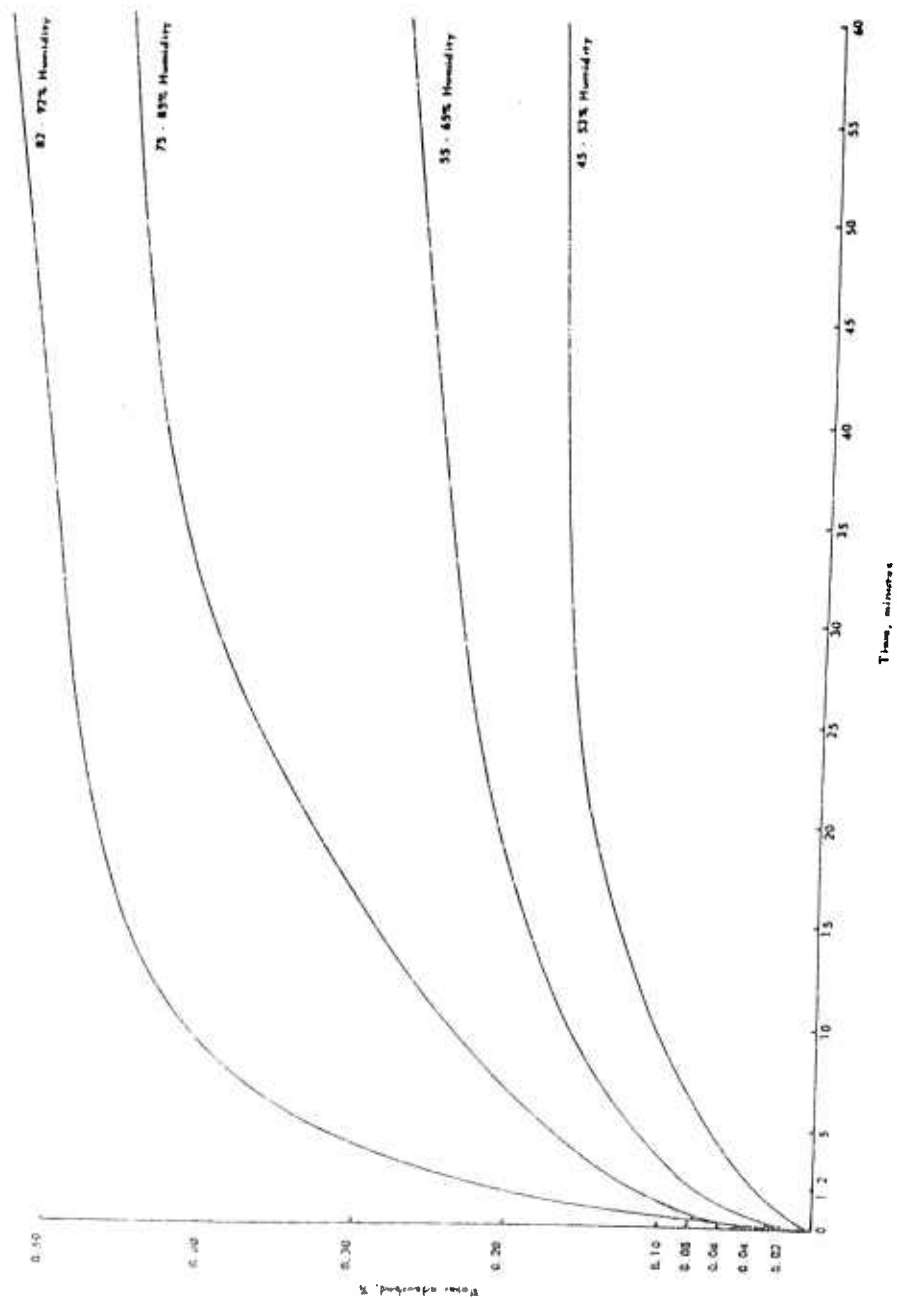


Fig 1 Hygroscopicity of Dextrinated Lead Azide Temperature Range, 20.0°C - 22.2°C

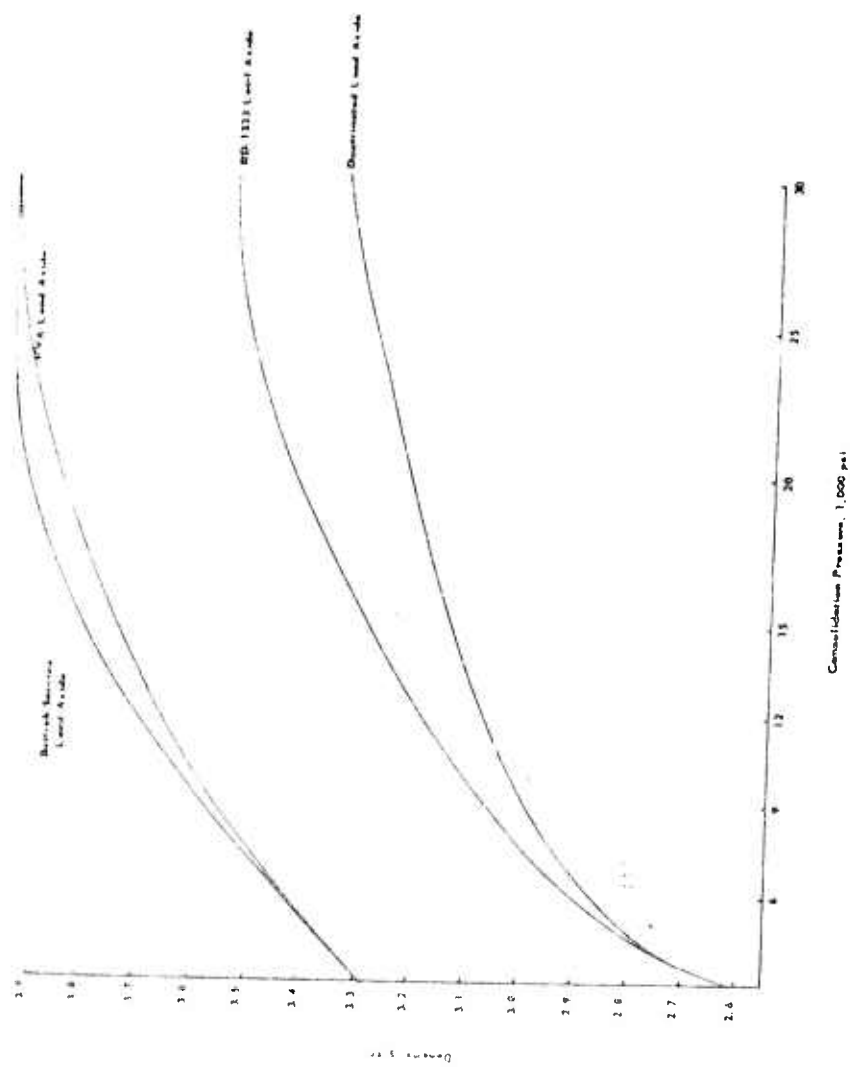


Fig 2 Pressure-Density Relationship of Lead Azide

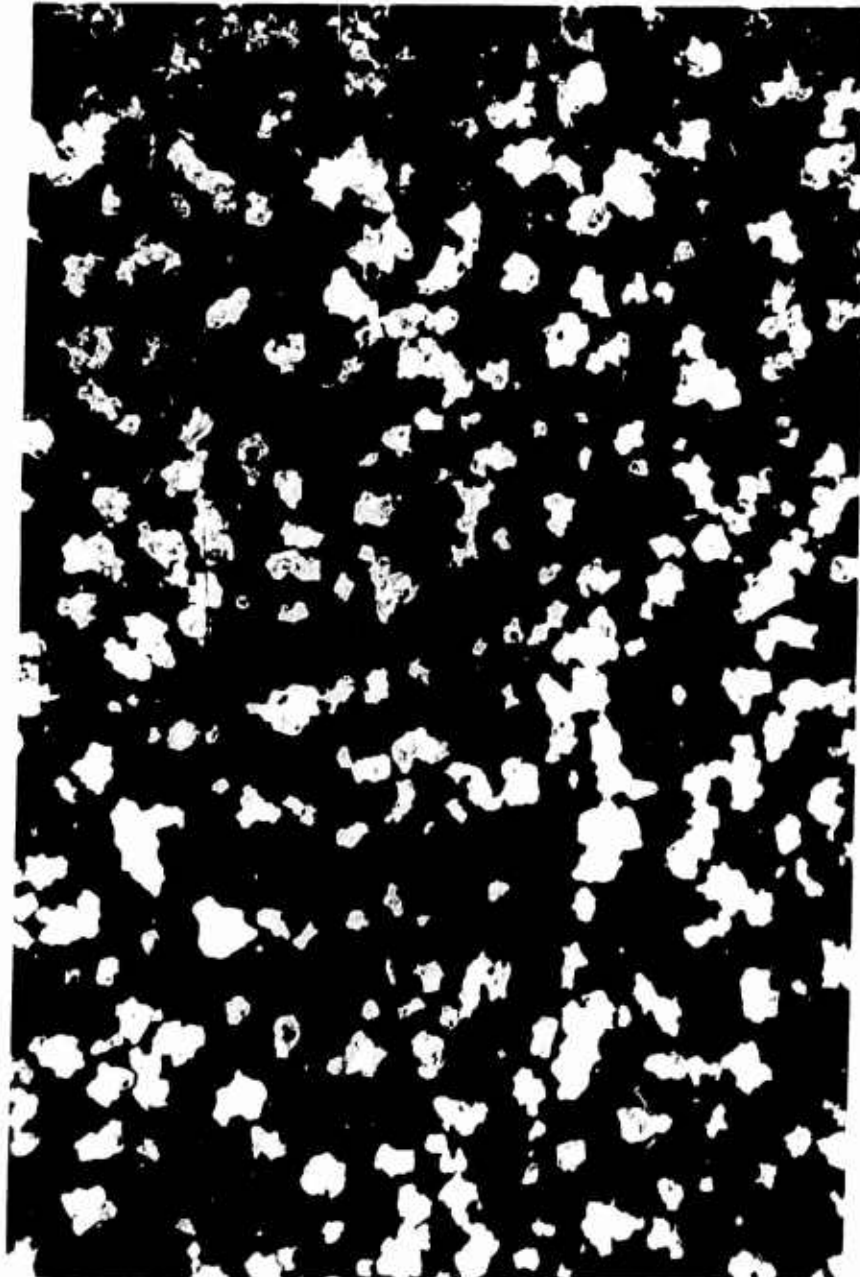


Fig. 3. Dextrinated Lead Azide (magnification 150 $\times$)



Fig. 4 RD 1333 L. 1000 Hz (magnification 150x)



Fig. 5 Polyvinyl Alcohol Lead Azide (magnification 150x)



Fig. 1. Lead azide (magnification 150x)

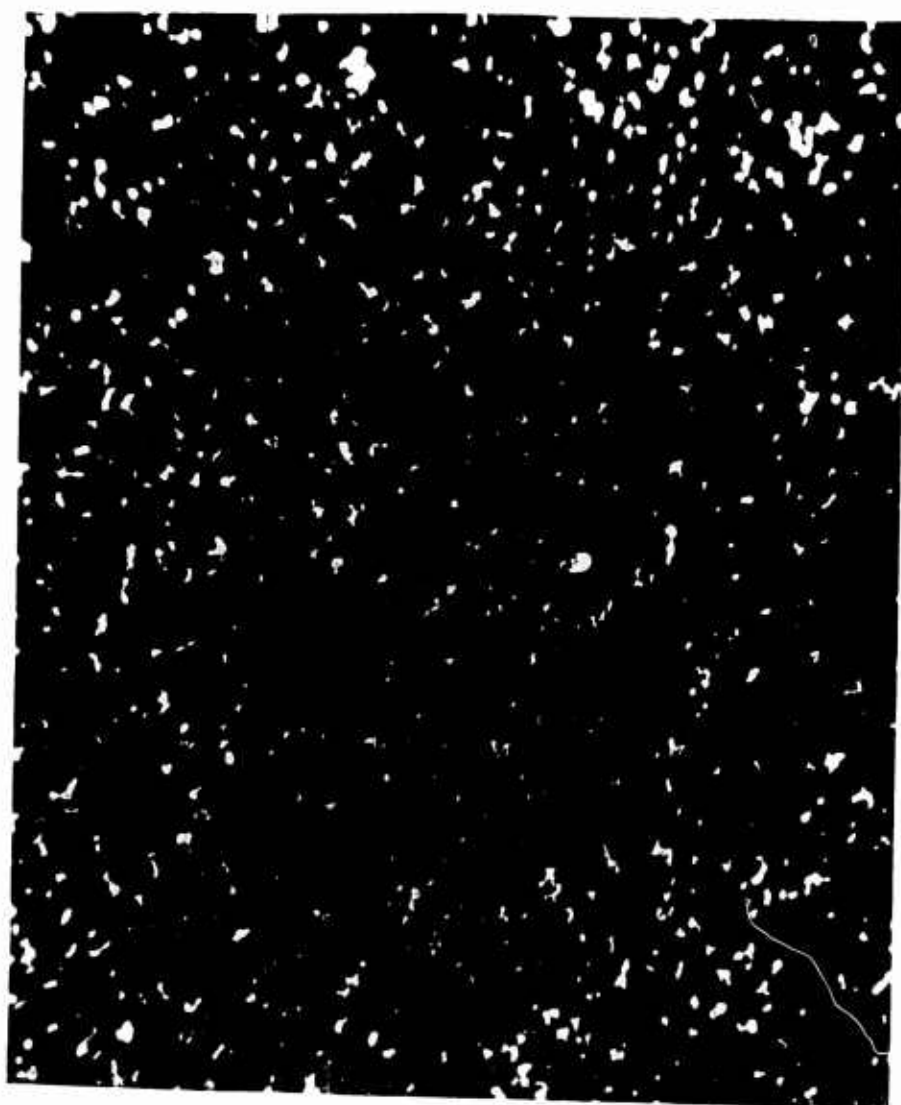


Fig. 7 Colloidal Lead Azide (magnification 150 $\times$)



Fig 8 Dextrinated Colloidal Lead Azide (magnification 500x)

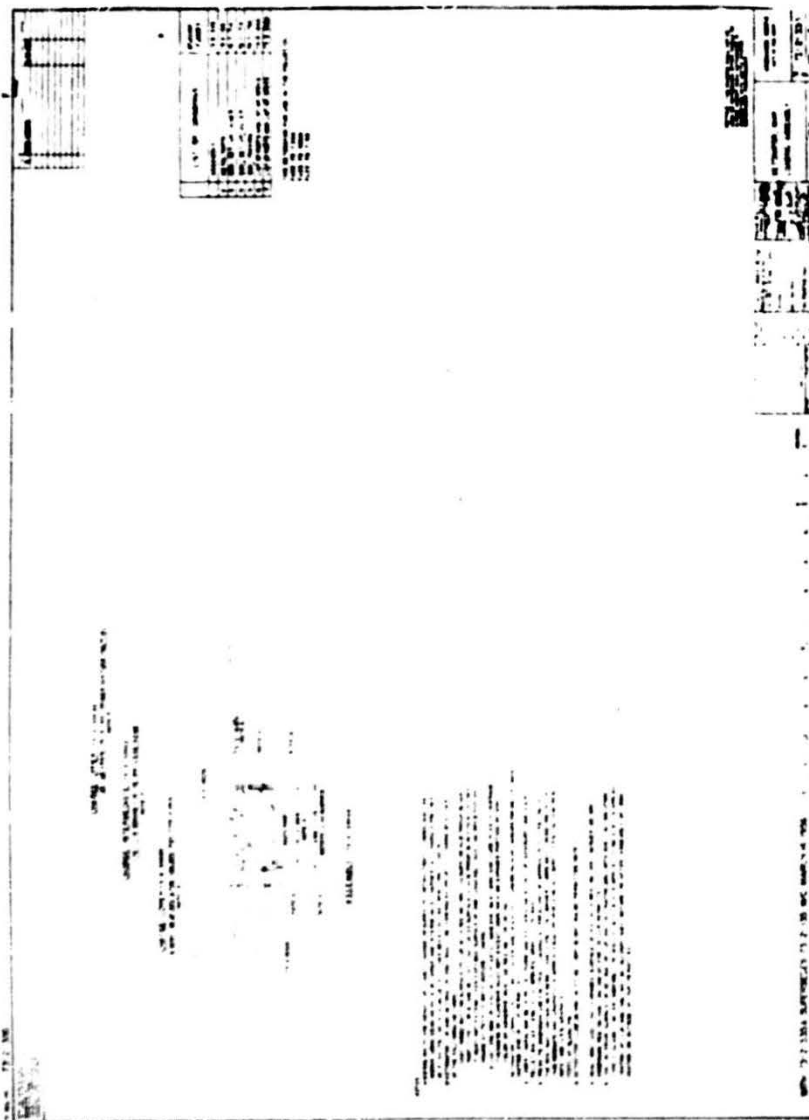


Fig 9 Loading Assembly for M47 Detonator

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2. Lead azide--Chemical analysis
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1. Lead azide
2. Detonators

- I. Wagner, R. L.
Ag
II. Ord Proj TN1-2707
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UNITERMS

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Azide
Detonator
Detonator
Initiator
M47
20 mm

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UNITERMS

RD-1333
Polyvinyl alcohol
Colloid
RDX
British
Service
PVA
Wagner, R. L.
Ord Proj TN1-2707 AG
DA Proj 505-01-003

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UNITERMS

RD-1333
Polyvinyl alcohol
Colloid
RDX
British
Service
PVA
Wagner, R. L.
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Detonator
Destriate
Initiator
M47
20 mm

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A minimum of 25 mg RD-1333 lead azide or 30 mg PVA lead azide was required to initiate RDX in the M47 detonator as compared with 90 mg for destriated lead azide. Neither RD-1333 nor PVA was hygroscopic, but destriated lead azide picked up over 5% moisture in 35 minutes at 82%-92% relative humidity. RD-1333, PVA, British Service, colloidal, and destriated colloidal lead azide had impact sensitivities of 5, 4-5, 2, 2, and 3 inches, respectively, using the 2-kg weight, as compared with 4-6 inches for destriated lead azide.

UNCLASSIFIED
UNITERMS

RD-1333
Polyvinyl alcohol
Colloid
RDX
British
Service
PVA

Wagner, R. L.
Ord Proj TN1-2707 AG
DA Proj 505-01-003

UNCLASSIFIED

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LEAD AZIDES FOR USE IN DETONATORS

Robert L. Wagner

Technical Report 2662, January 1960, 37 pp. tables, figures.
DA Proj 505-01-003, Ord Proj TN1-2707 Ag.
Unclassified Report

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1. Lead azide
2. Detonators

- I. Wagner, R. L.
II. Ord Proj TN1-2707
Ag
- III. DA Proj 505-01-003
- IV. RD-1333

UNITERMS

Lead Azide
Azide
Detonator
Dextrinate
Initiator
M47
20 mm

UNCLASSIFIED

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