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DEVELOPMENT OF RDX COMPOSITION CH-6 (U)

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U. S. NAVAL ORDNANCE LABORATORY

WHITE OAK, MARYLAND

CONFIDENTIAL

DEVELOPMENT OF RDX COMPOSITION CH-6 (U)

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ABSTRACT: A resume is given of the development of RDX composition CH-6 at the Naval Ordnance Laboratory, White Oak. Some background concerning the specification tests is presented. Comparative sensitivity data for CH-6 and tetryl are also given along with a discussion of the advantages of the "CH-6". CH-6 is superior to tetryl in output strength and in its ability to withstand elevated temperatures. Its sensitivity has been carefully adjusted to be essentially that of tetryl. Consequently it can be substituted for tetryl in any booster or lead for which reliability has already been demonstrated for tetryl without impairing this established reliability. Pelleting characteristics of CH-6 are good.

Explosions Research Department
U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

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The work reported here was carried out over a number of years and had for its goal the compounding of a booster type explosive superior to tetryl from the standpoint of thermal resistance and output. It was essential that the new explosive be about as sensitive as tetryl, but no more sensitive than tetryl. The work was carried out under Task Explosives Applied Research 301-664/43006/08 and has resulted in a new composition which should find increasing use in fuze explosive trains.

This report is circulated for information purposes only and is not to be used as a basis for action. The explosive CH-6 has been recommended for release by the Naval Ordnance Laboratory. It is described in MIL-R-21723, Military Specification RDX Composition CH-6, 14 December 1958 and in NavOrd OD 10607, Advisory Manufacturing Process for RDX Composition CH-6, 1 May 1958.

A number of people at the Naval Ordnance Laboratory have been instrumental in developing CH-6. Those who have been directly involved in the development include, among others, Dr. R. McGill, Mr. R. H. F. Stresau, Mr. J. B. Christian, Mr. L. D. Hampton, Mr. J. N. Ayres, and Mr. I. Kabik.

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By direction

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INTRODUCTION

CH-6 is an RDX explosive composition containing small quantities of calcium stearate, graphite, and polyisobutylene which are added to serve as binders or desensitizers. The mixture was developed as a replacement for tetryl in applications which require increased resistance to heat or a greater output than that obtained from tetryl.

Tetryl has been used quite extensively as the explosive in leads and boosters of ordnance items. However, it has a serious limitation in its greater tendency than certain other explosives to explode (cook-off) when subjected to high temperatures, such as might be encountered in certain modern weapon environments. Various instances exist wherein measurements of the cook-off temperature of tetryl and other explosives have been made under varying conditions. One such test is that made by National Northern and reported in reference (1). In this test the explosive was placed in an oven and the temperature raised to a predetermined value. Then the heat was shut off and the explosive observed to see whether or not an explosion occurred. The lowest temperature to which the oven had to be raised to produce an explosion was recorded as the cook-off temperature. In this test tetryl cooked-off when the oven was raised to a temperature of 140°C, while RDX did not cook-off until a temperature of 180°C was reached.

Since RDX has better cook-off characteristics than tetryl it would be the preferable explosive for use in ordnance subjected to temperatures approaching and exceeding the cook-off temperature of tetryl. RDX also has a greater output so that an RDX lead or booster would be effective under circumstances in which a tetryl lead or booster might give marginal initiation of the next charge. However, booster pellets made of RDX are not satisfactory, since they break up easily upon handling. Furthermore, pure RDX is somewhat more sensitive than tetryl in both the impact and gap tests. Since the Navy considers tetryl to be the most sensitive explosive which may be used beyond the safety interruption of a fuze explosive train, pure RDX cannot be considered in this application. In this situation one thinks at once of the possibility of adding a small amount of some material to the RDX which will act both as a binder and as a desensitizer. Wax has been used with RDX for this purpose. Composition A is a 91/9 mixture of RDX and wax. This quantity of wax reduces the sensitivity more than is desired for an explosive which is to be used in leads and boosters. The addition of approximately 3 percent wax desensitizes RDX until it is comparable to tetryl. Studies of this mixture are reported in references (2) and (3).

An RDX/wax mixture is not entirely satisfactory since it tends to adhere to the mold when pressed. When using an automatic pelleting machine this tendency leads to breaking of the pellet when ejected from the machine. This is particularly troublesome with larger diameter pellets (3/4-inch or greater). For detonators and leads the Army has used RDX with the addition of 0.5 percent of either calcium resinate or calcium stearate and 0.5 percent of graphite. For boosters RDX containing from 1.5 to 1.7 percent stearic acid and 0.25 percent graphite has been used. This mixture is not compatible with lead azide and is therefore not satisfactory for use in detonators. Cohesion of this material is not all one could desire and pellets larger than about 1.2 inches in diameter are not practicable.

RDX COMPOSITION CH-4

The mixtures previously described were ordinarily made mechanically by mixing the ingredients together while dry, or by a water slurry method in which the separate components were suspended together in water and mixed, after which the water was filtered off leaving one component coated on the other. Such methods do not always result in a uniform coating of the diluent on the RDX. In order to improve this feature a study was begun of the possiblity of coating the RDX by precipitating a stearate from a solution as the result of a chemical reaction. If RDX is suspended in a water slurry in which sodium stearate is dissolved the addition of calcium chloride will cause a reaction forming calcium stearate and sodium chloride. The calcium stearate, being insoluble in water, will be precipitated and will coat the RDX particles. Other metallic elements such as magnesium can be substituted for the calcium in this process. Several mixtures of this type, containing different percentages of the stearates of calcium or magnesium, were made and tested to determine their sensitivity and pelleting characteristics. These investigations are reported in reference (4). The tests used were the impact sensitivity test, reference (5), the small scale gap test, reference (6), and a tumble test. This test is described in reference (4). These tests indicated that it was possible to obtain a satisfactory sensitivity by this method but the pellets were too fragile as judged by the tumble test. In order to remedy this difficulty a small amount of polyisobutylene was added to the mixture. After some experimentation a mixture of RDX/magnesium stearate/polyisobutylene (97.80/1.45/0.75) was settled upon for further testing in a fuze train. This mixture, which was at first called H-4 but later known as CH-4, was more effective than tetryl when tested as the booster explosive in a fuze explosive train. CH-4 was tested in one fuze design in which it was desired to determine the minimum length of booster which would give reliable performance. When using CH-4 as the booster explosive a length of only 0.25 inch was required while the length of a tetryl booster required under the same conditions was 0.32 inch. The sensitivity of this mixture as measured in both the impact and gap sensitivity tests was sufficiently similar to that of tetryl to be considered satisfactory, reference (4). Pellets subjected to the tumble test showed some superiority over those obtained with tetryl.

Having been shown to be satisfactory in these respects the mixture was next tested in automatic pelleting machines. Ten pounds of the material were prepared and sent to Picatinny Arsenal with a request that its suitability for use in automatic pelleting machines be determined. The results of this test showed that it was too sticky to work well in these machines. The powdered material would not flow from the hopper of the machine satisfactorily.

RDX COMPOSITION CH-6

In order to improve the flow characteristics of the CH-4 the proportion of polyisobutylene was reduced from 0.75 to 0.5 percent. At the same time it was decided to substitute calcium stearate for the magnesium stearate of the CH-4 mixture. The result was RDX/calcium stearate/polyisobutylene (98.0/1.5/0.5). Decreasing the amount of polyisobutylene improves the flow characteristics at the expense of some decrease in pellet strength. Results of tumbling and gap sensitivity tests are reported in reference (7). The loss in weight in the tumbling test was slightly greater with this material than with tetryl, being 0.56 and 0.32 percent respectively. Gaps across which initiation were obtained 50 percent of the time in the small scale gap test were 0.146 inch for this mixture and 0.150 inch for tetryl when confined in brass. When aluminum confinement was used the gaps at which initiation occurred 50 percent of the time were 0.088 and 0.093 inch respectively. These differences are not significant.

Tests were made by the Naval Ordnance Plant, Macon, Georgia, to determine the suitability of this mixture for use in automatic pelleting machines. As a result of these tests, it was decided to add a small percentage of graphite to increase the flow of the material. The final composition thus arrived at was RDX/calcium stearate/polyisobutylene/graphite (97.5/1.5/0.5/0.5). This is the mixture which is known as CH-6.

CH-6 has several advantages over tetryl for use as the explosive component of a lead or booster. The chief of these are increased stability when exposed to high temperatures and a greater output for an element of a given size. Tests have been made of the effect of exposure to heat on CH-6 and tetryl and are reported in reference (8). The explosive pellet was heated by exposure to a stream of hot air. The temperature of the pellet was measured by means of thermocouples and this temperature was plotted as a function of the time of exposure to the hot air stream. Under the conditions of this test tetryl pellets showed a run-away reaction after 4 to 5 minutes exposure while CH-6 pellets withstood the heat for 8 to 10 minutes.

Tests which demonstrate the greater output of CH-6 as compared with that of tetryl have been made using the test arrangement described in reference (9). These are Bruceton type tests of fifteen shots each in which the thickness of a wax barrier is varied. Main charges of TNT and H-6 were initiated by boosters of tetryl and CH-6 through a wax spacer. The thickness of spacer for which 50 percent initiation was observed is given in Table I.

Table I

Wax Spacer Thickness (in inches)
for 50 Percent Initiation in Booster Test

	Main Charge	
Booster	TNT	H-6
Tetryl	0.865	1.075
CH-6	1.017	1.275

The standard deviation of these values is on the order of 0.020. The CH-6 booster initiated the main charge through a 20 percent greater wax spacer than did a tetryl booster.

Sensitivity to bullet impact of CH-6 as compared with that of tetryl was measured by the Naval Ordnance Laboratory using a test similar to that described on page 49 of reference (10) using a caliber .50 bullet. In the standard bullet sensitivity test the explosive is contained in a bomb made of a piece of cast iron pipe 3 inches long and 2 inches in diameter with a cap on each end. CH-6 and tetryl were also tested with the pipe having a cap at one end only and also when contained in a cardboard tube in place of the pipe. The results, as given in Table II, show the two explosives to be of comparable sensitivity.

Table II

Bullet Sensitivity of CH-6 and Tetryl
(Number of Explosions/Number of Trials)

	CH-6	Tetryl
In pipe with two caps	1/9	1/9
In pipe with one cap	1/11	1/10
In cardboard tube	9/11	7/9

On the basis of a number of sensitivity tests it is concluded that there is no significant difference in sensitivity between CH-6 and tetryl.

MANUFACTURE AND TEST OF RDX COMPOSITION CH-6

The Holston Defense Corporation was asked to investigate the problems connected with large scale production of CH-6. Several variations of the mixing procedure were tried which differed from each other in the order in which the components were added to the mixture. Ten pounds of each of five variations were made and sent to the Naval Ordnance Plant, Macon, for pelleting tests. On the basis of the results of these tests and also indications on the part of the Holston Defense Corporation as to difficulties likely to be encountered in one method of preparation as compared with another, a choice was made among the five procedures. The procedure adopted is described in reference (11) and is essentially as follows:

The polyisobutylene is dissolved in toluene.

Sodium stearate is mixed with water and calcium chloride dissolved in water in the desired quantities.

A water slurry of RDX is heated to 75°C in an agitated, jacketed vessel and the polyisobutylene-toluene solution added slowly.

The graphite is mixed with the sodium stearate and this mixture added to the RDX slurry.

After a short period of agitation the calcium chloride solution is added to the mixture. The resulting reaction precipitates calcium stearate onto the RDX.

The toluene is removed by distillation and the slurry cooled to about 50°C.

The mixture is then filtered and washed with distilled water after which it is dried at 70°C.

Before the final product is accepted tests are made of its sensitivity, output, and other desired characteristics. These tests are described in detail in reference (12).

The impact sensitivity is measured using equipment similar to that described in reference (5). The sensitivity of tetryl is determined by finding the greatest height at which fifteen trials result in no explosions. Fifteen trials are then made with CH-6 at 90 percent of this height and should result in no burning or explosions. Material passing this test should not be significantly more sensitive than tetryl with respect to impact sensitivity.

Sensitivity to initiation by shock is tested by attempting to initiate a pellet of CH-6 by a lead acting through an aluminum barrier. If the CH-6 pellet is initiated so as to produce an appreciable dent in a steel block it is considered to have fired. In setting up this test no attempt was made to have the aluminum barrier of such thickness that the CH-6 pellet would never be initiated, but rather to choose a thickness through which only a few percent of the CH-6 pellets would fire. Tests made with tetryl under these same conditions indicate that one could expect 10 or more percent of the tetryl pellets to fire. Material passing this test should not be significantly more sensitive than tetryl with respect to shock sensitivity.

A similar test is used to determine whether or not the output of a CH-6 booster is satisfactory. A thinner aluminum barrier is used and the result of a trial is considered a success if the dent produced in the steel block is equal to or greater than a certain specified value.

In both the output and the sensitivity tests the specification calls for testing fifteen pellets. If all are satisfactory the material is accepted. If there is one unsatisfactory pellet an additional fifteen are tested. If all of these are satisfactory the material is accepted.

The ability of CH-6 pellets to withstand handling is measured by means of a tumble test. Five pellets 0.50 inch in diameter and 0.50 inch thick pressed at 10,000 psi are weighed and placed in a can for tumbling. The closed can is rotated for 10 minutes with the axis of rotation being perpendicular to the axis of symmetry. The loss in weight observed under these conditions is taken as an inverse measure of the resistance to handling.

A density of 1.64 ± 0.03 gm/cm^3 when pressed at 10,000 psi is specified. The volume of a pellet is determined by finding its loss of weight when immersed in water.

Tests to determine the moisture content by loss in sample weight and the acidity or alkalinity are described in reference (12). The composition as determined by chemical analysis set forth in the specification is RDX, 97.50 ± 0.50; calcium stearate, 1.50 ± 0.15; graphite, 0.50 ± 0.10; polyisobutylene, 0.50 ± 0.10. The detailed procedure for these determinations is given in reference (12).

SUMMARY

The resistance of explosives to cook-off is becoming of increasing importance as the use of modern high speed missiles increases. The increased output, which allows the size of the booster to be decreased, is also important in connection with miniaturization of boosters in order to provide more space for other features. CH-6 is superior to tetryl in both respects without having a sensitivity greater than that of tetryl. On the other hand its sensitivity has not been made less than that of tetryl. Thus it should be possible to substitute CH-6 for tetryl in any booster or lead, for which reliability has already been demonstrated for tetryl, without impairing this established reliability. In fact some increased reliability may be achieved. Pelleting characteristics of CH-6 are good. The ingredients of CH-6 are all readily available and the mixing process is simple. Consideration of these points leads to the conclusion that CH-6 is superior to tetryl as a booster explosive.

Table III contains a summary of comparative properties of CH-6 and tetryl.

Table III

Comparison of CH-6 and Tetryl for Boostering Capabilities, Sensitivity, and Stability

		CH-6	Tetryl
1.	BOOSTERING DETONATION ACROSS A GAP *		
	Gap (inches) for 50 percent transmission of detonation.		
	Initiating TNT	1.017	0.865
	Initiating H-6	1.275	1.075
2.	IMPACT SENSITIVITY **		
	Drop height (centimeters) at which initiation occurs 50 percent of time on NOL machine.	26	27
3.	SMALL SCALE GAP SENSITIVITY TEST **		
	Gap (inches) across which the explosive is initiated by lead azide 50 percent of the time.		
	In brass confinement	0.146	0.150
	In aluminum confinement	0.088	0.093
4.	BULLET SENSITIVITY TEST ***		
	Number of explosions/Number of trials		
	In pipe with two caps	1/9	1/9
	In pipe with one cap	1/11	1/10
	In cardboard tube	9/11	7/9
5.	VACUUM STABILITY		
	cc gas evolved per gram of explosive in 48 hours at 100°C	0.10	0.22
6.	COOK-OFF ****		
	Cook-off temperature (°F)	385-406	240-320

Table III (cont'd.)

		CH-6	Tetryl
7.	RESISTANCE TO ABRASION **		
	Percentage loss in weight after tumbling test.	0.56	0.32

* NOLM 10336
** NavOrd Report 4320
*** Army Tech. Manual TN 9-1910
**** NavOrd Report 4383

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