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RDX/CALCIUM-STEARATE BINARY SYSTEM
EXPLOSIVE SENSITIVITY CALIBRATION

UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

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RDX/CALCIUM-STEARATE BINARY SYSTEM
EXPLOSIVE SENSITIVITY CALIBRATION

By J. N. Ayres
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ABSTRACT: The Small Scale Gap Test sensitivity and output of RDX/Calcium-Stearate mixtures ranging from 0.59% to 23.75% Calcium Stearate have been determined for 4, 8, 16, 32 and 64 KPSI consolidating pressures. By choice of pressure and composition changes can be made with sensitivities from 3.4 to 7.8 DBg shock sensitivities. Although these mixtures can be used to satisfy the immediate needs for explosives for the VARICOMP measurement of weapon explosive train safety and reliability, explosive systems should be developed wherein composition control to obtain specific sensitivity and output is less critical.
RDX/CALCIUM-STEARATE BINARY SYSTEM EXPLOSIVE SENSITIVITY CALIBRATION

The VARICOMP method of penalty testing has been developed to permit demonstration of the high detonation-transfer safeties and reliabilities that are needed in modern weapon system explosive trains. A necessary adjunct of the VARICOMP method is a supply of explosive compounds or mixtures with sensitivities that can be selected in relation to the particular explosive system being studied.

The present report deals with the calibration, at the request of and funded by NOL, Corona, of an RDX/Calcium-Stearate binary system used for VARICOMP testing. The information is of interest to those who will be using the specific compositions from which the samples were taken and to those who are considering the possibility of utilizing the VARICOMP process. From this report can be obtained an idea of the scope of the work needed to calibrate a VARICOMP explosive series.

R. E. ODENING
Captain, USN
Commander

C. W. ARONSON
By direction
# UNCLASSIFIED
## NOLTR 63-91

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REFERENCES

RDX/CALCIUM STEARATE BINARY SYSTEM EXPLOSIVE SENSITIVITY CALIBRATION

Introduction

1. The VARICOMP(1) method of detonation-transfer probability assessment is based on the use of explosives of known sensitivities and/or outputs. For instance, if it can be shown that detonation will transfer with a known probability into a desensitized acceptor explosive, then logically the probability of transfer into a non-desensitized acceptor explosive under the same conditions will be higher. If the relative sensitivities of the explosives are known, it is possible with limited testing to determine the points of extremely high detonation transfer probabilities of a given weapon utilizing the non-desensitized explosive.

2. Direct determination of high firing probabilities by actual firing of weapons requires prohibitively large weapon samples. The VARICOMP method has been used to predict, with less than 100 shots, (mostly in simulated hardware) reliabilities in excess of 99.99% at better than 95% confidence. A direct observation of this performance level and confidence would require in excess of 10,000 trials.

3. The VARICOMP method requires the use of explosive charges of two or more controllable and differing sensitivities (or outputs). For the measurement of fuze explosive train detonation transfer probabilities a fifteen-member series of RDX/Calcium-Stearate mixtures has been prepared, ranging from 0.59 to 23.75% calcium stearate. The calcium stearate additive acts both as a desensitizer and as a binder for pelletizing. In general, the greater the calcium stearate content the less sensitive and the more compressible the mixture.

4. It is the purpose of this report to present the experimental data and to show the interrelationships between consolidating pressure, charge density, composition, and sensitivity of the RDX/calcium stearate binary explosive system. A close inspection of the data reveals certain minor inconsistencies which it is believed could be remedied by redetermination of the chemical composition of certain of the mixes. Even without these re-determinations the calibrations permit full use of the various mixes in VARICOMP testing.

(1) References are on page iv.
Preparation of the Explosive

5. The advisory information in Appendices A and B was furnished to the explosives manufacturer (Holston Ordnance Works) for the preparation and chemical analysis of the mixes. The manufacturer was limited by his available equipment to about 100 pounds of product per run. For orders greater than 100-pounds, 100 pound sub-batches were blended. A sample was taken of each sub-batch for chemical analysis and to permit future sensitivity testing.

6. Certain sub-batches were not analyzed. However, all samples (both batch and sub-batch) which were received at NOL were given unique identification numbers. Appendix C is a compilation of batch and sub-batch identification and analytical information.

Sensitivity Testing

7. The sensitivity of each of the fifteen main (composite) batches was determined using the Small Scale Gap Test. (2) Twenty bodies were loaded at each of five consolidating pressures: 4.0, 8.0, 16.0, 32.0, and 64.0 K psi. Two of the bodies at each of the five pressures were fired with no attenuation between the donor and acceptor. The average dent output of each pair of zero-gap shots was reported as the output. The eighteen shots remaining in each group were then fired, using a Bruceton sequential stair-step plan. In some few instances, when the firing of two shots at zero gap was omitted, all twenty pieces in the group were fired according to the Bruceton plan. In these cases there are no dent output values quoted.

Presentation of Results

8. The charge density, sensitivity, and output data are reported for each of the fifteen compositions at each of the five consolidating pressures in Appendix D. The average density and the standard deviation of an individual density reading are reported in units of grams/cc. The average density is also reported as percent of theoretical maximum density (TMD). The TMD for each of the fifteen mixes was computed assuming a simple additive mixture of RDX (TMD = 1.81 grams/cc) and calcium stearate (TMD = 1.04 grams/cc) according to the reported chemical analysis. The sensitivity is reported in units of DBg (the gap Decibang) which is a normalizing
transformation of the input dosage. It can be thought of as being proportional to the relative shock strength applied to the explosive in the acceptor. The sensitivity parameters given are: AVG level, the level at which 50% response would be expected; the standard deviation of an individual observation; and the standard deviation of the AVG level.

9. In order to convey an idea of the accuracy of, and the effort involved in, this calibration the following facts are presented:

a. Fifteen hundred Small Scale Gap Test shots were fired plus over a hundred more shots to check the output quality of donors and detonators.

b. Each charge holder inside diameter, and each explosive column length were measured to about 0.05% accuracy.

c. Charge weights were obtained by weighing the bodies before and after loading. Every determination was based on two independent observations which were not accepted unless they agreed within 1 milligram. (The charge weight is in the order of 1.2 to 1.5 grams and body weight 150 to 160 grams).

d. The standard deviation of charge weight and of density for any twenty bodies representing a particular combination of density and composition did not exceed 0.2% and were usually about 0.05 to 0.1%.

e. The accuracy of dent measurement is about 0.5 mils

\* When the shock is derived from the standard SSOT donor through a thickness of Lucite attenuator the DBg is computed as

\[ \text{Input (DBg)} = 10 \log \left( \frac{\text{Reference Thickness}}{\text{Attenuator Thickness}} \right) \]

The reference thickness being 1.0 inch and the attenuator thickness being reported in mils, the expression reduces to

\[ \text{Input} = 30 - 10 \log (\text{attenuator thickness}) \]
Effect of Composition on Sensitivity and Output

10. Figures 1 through 6 have been prepared to show the effect of composition on the sensitivity of the explosive mixtures. With the consolidating pressure held constant, the mixtures become less sensitive with increasing calcium stearate content. Furthermore, the rate of desensitization is greatest at the lowest percentages and decreases as the additive is increased.

11. A curious trend can be seen in the region of the 2.54, 3.34, 4.79 and 6.07% calcium stearate mixes. The sensitivities of the 4.99% mix seem to be low compared with the 3.34 and 6.07% mixes. It is unlikely that such a trend could arise from sampling error.

12. One source of this anomaly could be faulty chemical analysis, which would shift, horizontally, all five sensitivity points for a given composition. Accordingly, two mixes were re-analyzed with the following results:

<table>
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<th>Re-Analysis (by NOL)</th>
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<tr>
<td></td>
<td>X Number</td>
<td>Replicates Average</td>
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<tr>
<td>358</td>
<td>4.86</td>
<td>4.92</td>
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<tr>
<td></td>
<td>5.03</td>
<td>4.99</td>
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<td></td>
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<td></td>
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<td>362</td>
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<td>6.61</td>
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<td></td>
<td>6.04</td>
<td>6.52</td>
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An inspection of the sensitivity curves (Figures 1 through 6) shows that replotting with the 4.94 and 6.57% data coordinates would permit redrawing the curves in a way which would give somewhat better agreement with the observed data.
13. If there were a gross error in the composition of either of these two mixes (or for any of them, for that matter) it was reasoned that this would give rise to a discrepancy in the output of the explosive as observed on the SSQT witness block with no attenuation between the donor and the acceptor. To check this concept the following scheme was used:

a. It has been found (references 1 and 2) for a fixed geometry of highly confined explosive such as in the SSQT, that the steel dent output reading is linearly related to the detonation velocity and the detonation velocity is in turn linear with the density. Since the acceptor column length and volume are the same for all tests, it seems reasonable to assume that the dent should be proportional to the amount of RDX in the acceptor.

b. The amount of RDX can be computed as the product of the volume of the acceptor, the charge density, and the proportional RDX content.

c. Since the volume is constant the variable factor will be the product of the density and the proportional RDX content, in equation form

\[ P = \left( \frac{\% \text{ RDX}}{\% \text{ RDX}} \right) \frac{\rho}{100} \]

where \( P \) is the partial density of RDX and \( \rho \) is the charge density.

d. The output was plotted against the partial density of RDX (Figure 7). A straight line fit of these data was made using the least squares technique.

This procedure yielded an equation relating the dent and the partial density of RDX (and thus the density and composition of the mix).

\[ D = 33.76 P + 9.29 \]

where \( D \) is the dent in mils.

14. The usual statistical procedures were used to test how well the data were described by the above equation. The tests were used for all of the data points and also for each of the data groups for the fifteen mixtures. In all cases a high degree of correlation was found, with the least satisfactory fit being for the 0.59% calcium stearate mix. In particular it
should be noted that the 4.99 and 6.00\% calcium stearate mix data points straddle the line. If the calcium stearate content of these mixes were assumed to be off by about 2\% from the stated values (as high as 7.0 and 8.0 respectively or as low as 3.0 and 4.0), the plotted dent values would then no longer be found to straddle the regression line. This is certainly no substitute for an accurate chemical analysis to determine a chemical composition. It is however a check on the consistency of the observed behavior.

15. It does not seem that the irregularities in the sensitivity composition curves can be explained as being due solely to errors in estimation of composition. Further experimental work would be required to attempt to improve the curves. However, there are no immediate plans to pursue this effort. The explosives can be used satisfactorily for VARIOMP testing with the existing information. Perhaps somewhat less precision and sophistication can be obtained than might otherwise have been possible with smooth composition-sensitivity functions.

Effect of Consolidating Pressure on Sensitivity

16. The more generally useful relationships are those which show, for specific compositions, the effect of consolidating pressure or density upon sensitivity. These have been presented graphically in Figures D-1 through D-15 of Appendix D. Each datum point has a vertical line drawn through it, the length of which represents the expected error limits of the location of the fifty-percent firing level.

17. The minima, which are seen in the majority of the sensitivity-versus consolidating-pressure curves at about 8K psi, are not new phenomena. They represent the resultant of two competing mechanisms.

a. In general explosives become less sensitive to shock with increasing density and would therefore be expected to increase in sensitivity at the lower consolidating pressures.

b. As the explosive becomes less dense and the RDX particles in less intimate contact it is necessary that the detonation be stronger in order to bridge the increasing gap between particles.

18. A deeper insight into the system can be obtained by studying such things as the relationships between consolidating pressure, charge composition, and density (Figure 8), and also the rather novel graphic presentations of Figures 9 and 10. Calcium stearate acts as a diluent, a lubricant, and a binder. The dilution gives rise to the two effects already discussed--desensitization and reduction of output. The lubricating effect
can be seen in Figure 8. For loading pressures of 4 or 8K psi the higher the proportion of calcium stearate the nearer to the theoretical maximum density (TMD) are the charge densities. At the higher consolidating pressures it can be seen that the relative densities are maximized at intermediate calcium stearate proportions rather than at the higher levels. This also arises from the lubricating effect of the calcium stearate as evidenced by the greater spring-back which occurred. Spring-back is the term used to describe the expansion which is usually observed with pressed charges after the consolidating pressure is removed. The spring-back effect is limited in part by the friction between the acceptor walls and the explosive in contact with the walls. At the higher pressures the spring-back forces are large enough to overcome, at least partially, the wall friction forces.

Iso-Sensitivity Presentation

19. Figures 9 and 10 have been prepared in a manner analogous to the drawing of isobars and isotherms on weather maps. In Figure 9, the vertical coordinate is the consolidating pressure and the horizontal is the composition (plotted logarithmically) since these are the controllable variables. Smooth curves have then been drawn which represent the estimated loci for all the possible combinations of compositions and pressures which would be expected to have the indicated sensitivity. For the portions of the isosensitivity curves which are oriented more or less vertically the consolidating pressure has little effect on the sensitivity. Similarly when they are oriented more or less horizontally, then the dilution of the RDX by calcium stearate has relatively little effect on sensitivity.

20. For Figure 10 the vertical coordinate is the charge density rather than the consolidating pressure. Here, loci have been drawn for the 4, 8, 16, 32, and 63K psi consolidating pressures as well as for the isosensitivity points. In this presentation it can be seen that there are portions of the diagram where the isosensitivity curves are much closer together than elsewhere. In such portions, a relatively small error in composition or shift in density can bring about a considerable alteration in sensitivity. Since nearly any desired sensitivity can be achieved by a number of different combinations of the variable parameters, it seems sensible to select the composition and pressure so that the error in sensitivity will be minimized. Such a place would be where the isosensitivity lines are most widely separated.

Recommendations

21. This series of RDX/calcium-stearate mixtures is being used in the assessment of detonator-to-lead and lead-to-booster detonation transfer probabilities of a number of weapon explosive trains using the VARICOMP experimental approach. An ideal calibration of a VARICOMP explosive series would involve a smoothing of sensitivity data on the basis of chemical
composition to compensate for the variability introduced by the sampling error that is inevitable with the small sample size (18 or 20 shots per test) in the GO/WO-GO testing. In the present instance such smoothing would not be justified without further analytical and experimental investigation. Consequently, as a practical method of utilizing the explosives and their calibration data at the present state of knowledge, the following procedures are suggested for use.

a. Accept the reported values of sensitivity at each of the consolidating pressures as they are given in Appendix D.

b. To fabricate charges of a desired sensitivity select a combination of composition and pressure for which the least shift in sensitivity might arise due to an unfortunate choice. For instance, choose a combination for which the pressure is closest to a calibration pressure. Or choose a combination where there is a minimum change in sensitivity between the calibration pressure lying on each side of the chosen pressure.

c. If the explosive transfer system being tested shows an indication of being marginal so that a small error in the calibration might have serious consequences, verify the sensitivity of the combination by an SSMT calibration.

d. Assume that, for any other configuration than the SSMT acceptor, the various composition-pressure-sensitivity relations hold in the same relative manner.

22. The immediately preceding statement is made to emphasize the fact that the sensitivity of an explosive charge is strongly affected by its configuration. For instance, had the explosives been loaded into aluminum or plastic charge holders instead of brass the explosives would have shown a decreased sensitivity. Desensitization would also have been observed had the acceptor charge diameter been much smaller or much larger than the donor diameter.

Conclusions

23. Mechanically, the RUX/calcium-stearate system is less than ideal. When pressed into cups or cylindrical cavities it handles well except at high densities and pressures where excessive spring-back is encountered. The
spring-back can be controlled to some degree by using a dwell time of five or ten seconds on each increment, with the increment length being no greater than the charge diameter. Free pellets of the explosives, such as 1/2-inch diameter by 1/2-inch long, are fragile at best. At the higher concentrations of calcium stearate the pellet is apt to break up into a series of discs. At the very low concentrations the pellet will simply crumble into a heap of lumpy powder. However, by proper choice of composition and pressure it is possible to make pellets throughout the greater region of the sensitivity spectrum covered in the calibration testing.

24. With all of the aforementioned limitations this system of explosive mixtures is proving out in the VARICOMP method of assessing detonation transfer probabilities, as a powerful experimental tool.

25. Some binary mixtures in which both components are high explosives should be a considerable improvement over the RDX/calcium stearate mixtures. These explosives should be chosen, so that in the pure form one would be comparatively sensitive and the other insensitive. On the assumption that the sensitivity of a mixture would be predictable from the ratio of their relative quantities, it would be expected that an error in composition would have less of an effect on the sensitivity than is now the case for the RDX/calcium stearate system. With both components active there should be much less degradation of performance at the insensitive end, making it much easier to establish a criterion of fire. It should also be possible to select the explosives with some consideration of density, melting point, and other physical properties so that a better physical mixture could be obtained.
FIG. 1 THE EFFECT OF COMPOSITION ON THE 50% FIRRING POINT OF RDX/CALCIUM STEARATE MIXTURES LOADED AT 4 KPSI.
FIG. 2. THE EFFECT OF COMPOSITION ON THE 50% Firing Point of RDX/CALCIUM STEARATE MIXTURES LOADED AT 8 KPSI.
FIG. 3 THE EFFECT OF COMPOSITION ON THE 50% FIRING POINT OF RDX/CALCIUM STEARATE MIXTURES LOADED AT 16 KPSI.
FIG. 4 THE EFFECT OF COMPOSITION ON THE 50 % FIRING POINT OF RDX/CALCIUM STEARATE MIXTURES LOADED AT 32 KPSI.
FIG. 5 THE EFFECT OF COMPOSITION ON THE 50% FIRING POINT OF RDX/CALCIUM STEARATE. MIXTURES LOADED AT 64 KPSI.
FIG. 6 THE EFFECT OF COMPOSITION AND CONSOLIDATING PRESSURE ON THE 50% FIRING POINT OF RDX/CALCIUM STEARATE MIXTURES.
FIG. B: THE INTERRELATIONSHIP BETWEEN CONSOLIDATING PRESSURE, COMPOSITION AND DENSITY OF RDX/CAUCIUM STEARATE MIXTURES.
FIG 9 CONTOUR PLOT OF THE EFFECT OF CONSOLIDATING PRESSURE AND COMPOSITION ON THE SENSITIVITY OF RDX/CALCIUM STEARATE MIXTURES.
APPENDIX A

PROCEDURE FOR PREPARING A 100-POUND BATCH OF DESENSITIZED RDX

A.1 Let X be the numerical value of the desired percentage of RDX in the final product.

A.2 Prepare an RDX-water slurry by adding X pounds of RDX (JAN-R-398 Type B, Class A) to 10X pounds of distilled water at 70 to 80° Centigrade.

A.3 Prepare a sodium stearate solution by dissolving (100-X) pounds of sodium stearate (Technical Grade) in (1300-13X) pounds of distilled water at 70-80° Centigrade.

A.4 Prepare a calcium chloride solution by dissolving (75-0.75X) pounds of calcium chloride (0-C-104, Class 1) in (1500-15X) pounds of distilled water at 70-80° Centigrade.

A.5 Add the sodium stearate solution to the RDX slurry with rapid stirring.

A.6 With rapid stirring, add the calcium chloride to the RDX-sodium stearate mixture (addition should take from 15 to 30 minutes).

A.7 Filter and wash with distilled water until the effluent wash water is free of chloride ion. This can be detected by testing the wash water with a silver nitrate solution.

A.8 Dry the filtered and washed product at 70° Centigrade on trays over steam coils.
APPENDIX B

ANALYTIC PROCEDURE FOR RDX/CALCIUM STEARATE MIXES

B. 1 Procedure

B. 1. 1 Sample size should be set to yield approximately 0.3 gram of calcium stearate after the extraction of the RDX. From the standpoint of safety an upper limit of 3- to 5-gram sample size is recommended.

B. 1. 2 Standard dry powder sampling and sample blending procedures should be employed.

B. 1. 3 Medium porosity sintered glass crucible should be thoroughly washed, soaked in boiling acetone, dried and tared.

B. 1. 4 Sample should be weighed in the tared sintered glass crucible.

B. 1. 5 The weight loss by volatiles should be determined by weighing the sample and crucible after vacuum drying for one hour at 70° Centigrade and 50-millimeters Hg absolute pressure.

B. 1. 6 The RDX should be extracted by 8 washings of 20 milliliters each of boiling acetone. During each washing the sample should be triturated continuously with a tared glass stirring rod, in order to break all lumps.

B. 1. 7 The calcium stearate residue, crucible, and stirring rod should be vacuum dried for one hour at 70° Centigrade and 50-millimeters Hg absolute pressure.

B. 1. 8 The residue and glassware should be weighed after being allowed to cool for 30 minutes in a desiccator. The weight loss from the acetone extraction is taken as the amount of RDX and the weight of the residue as calcium stearate.
B. 2 Precautionary Notes

B. 2. 1 Particularly above about 6 percent of calcium stearate the analysis becomes rather difficult and subject to gross error due to poor analytic technique. The error seems to be due to incomplete RDX extraction which apparently is due to the tendency of the calcium stearate to form a protective coating on the surface of the RDX particles. The obvious approach of increasing the amount of washing with hot acetone is not considered advisable because of the increased chance of loss of calcium stearate.

B. 2. 2 Particularly when there seems to be an unacceptably high volatile content, (above 0.2 percent should be viewed with suspicion) there may have not been adequate washing of the mix during its manufacture. In such cases the presence of calcium chloride should be suspected since such a material would lead to hygroscopicity of the mix.

B. 2. 3 At the present time a specific procedure has not been developed for the quantitative determination of the chloride ion. A number of approaches seem promising. Perhaps the best one is to perform a replicate analysis as above except for the inclusion of an extra step between steps B. 1. 5 and B. 1. 6 which would include a water wash followed by a vacuum drying and reweighing of the residue and a quantitative precipitation of chloride ion from the filtrate.
APPENDIX C

<table>
<thead>
<tr>
<th>Manufacturer's Identification</th>
<th>NOL X Number</th>
<th>Average</th>
<th>Observed Error</th>
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<td>----</td>
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C-1

UNCLASSIFIED
APPENDIX C (continued)

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C-2
UNCLASSIFIED
### Percent Calcium Stearate

<table>
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<th>Manufacturer's Identification</th>
<th>MOL X Number</th>
<th>Average</th>
<th>Error</th>
<th>SSQT Data Location</th>
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<td>25</td>
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<td>----</td>
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<tr>
<td>26</td>
<td>382</td>
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<td>----</td>
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<tr>
<td>27</td>
<td>383</td>
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<td>----</td>
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<td>23.75</td>
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</table>
APPENDIX D

COMPOSITION:

0.83% CALCIUM STEARATE

SPECIFIED 1.0; DELIVERED 0.83;

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<tr>
<th>LOADING PRESSURE (KPSI)</th>
<th>DENSITY (GRAMS/CC) AVG</th>
<th>% TMD</th>
<th>SHOCK STRENGTH, DBG AVG</th>
<th>Δ</th>
<th>Δ M</th>
<th>OUTPUT DENT (MILS)</th>
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<tbody>
<tr>
<td>4</td>
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<td>0.0022</td>
<td>80.277</td>
<td>3.484</td>
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<td>3.991</td>
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<td>0.018* 62.8</td>
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<td>0.086</td>
<td>0.031 67.3</td>
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<td>97.682</td>
<td>6.432</td>
<td>0.142</td>
<td>0.047 68.6</td>
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</table>

* Δ M ESTIMATED

FIG. D-2 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X—NO. 349.
APPENDIX D

COMPOSITION:

1.65% CALCIUM STEARATE

SPECIFIED 2.0; DELIVERED 1.65;

<table>
<thead>
<tr>
<th>LOADING PRESSURE (KPSI)</th>
<th>DENSITY (GRAMS/CC)</th>
<th>% TMD</th>
<th>SHOCK STRENGTH, DBG</th>
<th>OUTPUT DENT (MILS)</th>
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<td>AVG</td>
<td>Δ</td>
<td>AVG</td>
<td>Δ</td>
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<td>95.497</td>
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<td>64</td>
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<td>0.0039</td>
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</table>

* ΔM ESTIMATED

FIG. D-3 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X-NO. 350.
APPENDIX D

COMPOSITION:

2.5% CALCIUM STEARATE
SPECIFIED: 2.8; DELIVERED: 2.5%

<table>
<thead>
<tr>
<th>LOADING PRESSURE (KPSI)</th>
<th>DENSITY (GRAMS/CC)</th>
<th>% TMD</th>
<th>SHOCK STRENGTH, DBG</th>
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<td>AVG</td>
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</table>

* & M ESTIMATED

FIG. D-4 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X-NO. 353.
APPENDIX D

COMPOSITION:

3.3\% CALCIUM STEARATE

SPECIFIED 4.0; DELIVERED 3.34;

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<th>LOADING PRESSURE (KPSI)</th>
<th>DENSITY (GRAMS/CC) AVG</th>
<th>% TMD</th>
<th>SHOCK STRENGTH, DBG AVG</th>
<th>A</th>
<th>&amp; M</th>
<th>OUTPUT DENT (MILS)</th>
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<td>4</td>
<td>1.4815</td>
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<td>83.842</td>
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<td>88.381</td>
<td>4.551</td>
<td>0.073</td>
<td>0.027</td>
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<td>93.537</td>
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</table>

* & M ESTIMATED

FIG. D-5 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X—NO. 354.
**APPENDIX D**

**COMPOSITION:**

4.99% CALCIUM STEARATE
SPECIFIED 5.6; DELIVERED 4.99;

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<th>LOADING PRESSURE (KPSI)</th>
<th>DENSITY (GRAMS/CC)</th>
<th>% TMD</th>
<th>SHOCK STRENGTH, DBG AVG</th>
<th>%</th>
<th>OUTPUT DENT (MILS)</th>
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</table>

* A M ESTIMATED

---

**FIG. D-6 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X−NO. 358.**
APPENDIX D

COMPOSITION:

6.07% CALCIUM STEARATE
SPECIFIED 8.0; DELIVERED 6.07;

<table>
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<th>DENSITY (GRAMS/CC) AVG</th>
<th>% TMD</th>
<th>SHOCK STRENGTH, DBG AVG</th>
<th>Δ</th>
<th>Δ M</th>
<th>OUTPUT DENT (MILS)</th>
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<td>86.655</td>
<td>5.363</td>
<td>0.326</td>
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<td>1.5076</td>
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<td>90.455</td>
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</table>

* Δ M ESTIMATED

FIG.D-7 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X—NO.362.
### APPENDIX - D

#### COMPOSITION:

9.16% CALCIUM STEARATE

SPECIFIED 12.0; DELIVERED 9.16;

<table>
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<th>DENSITY (GRAMS/CC)</th>
<th>% TMD</th>
<th>SHOCK STRENGTH, DBG</th>
<th>OUTPUT DENT (MILS)</th>
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<td>1.6497</td>
<td>0.0023</td>
<td>97.384</td>
<td>7.243</td>
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</tbody>
</table>

* & M ESTIMATED

**FIG. D-8** LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X - NO. 366.
COMPOSITION:

11.0% CALCIUM STEARATE
SPCIFIED 14.0; DELIVERED 11.05

<table>
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<tr>
<th>LOADING PRESSURE (KPSI)</th>
<th>DENSITY (GRAMS/CC) AVG</th>
<th>% TMD AVG</th>
<th>SHOCK STRENGTH, DBG AVG</th>
<th>M</th>
<th>&amp; M</th>
<th>OUTPUT DENT (MILS)</th>
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</thead>
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<td>89.725</td>
<td>6.086</td>
<td>0.073</td>
<td>0.027</td>
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<td>1.5611</td>
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<td>0.018</td>
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<td>96.688</td>
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<td>97.136</td>
<td>7.396</td>
<td>0.092</td>
<td>0.017</td>
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</table>

* & M ESTIMATED

FIG. D-9 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X - NO. 370.
APPENDIX D

COMPOSITION:

12.79% CALCIUM STEARATE
SPECFIED 16.0; DELIVERED 12.79;

<table>
<thead>
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<th>LOADING PRESSURE (KPSI)</th>
<th>DENSITY (GRAMS/CC) AVG</th>
<th>% TMD AVG</th>
<th>SHOCK STRENGTH, DBG AVG</th>
<th>Δ</th>
<th>Δ M</th>
<th>OUTPUT DENT (MILS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
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<td>93.520</td>
<td>6.173</td>
<td>0.116</td>
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* & M ESTIMATED

FIG. D-10 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X—NO. 374.
APPENDIX D

COMPOSITION:

14.16% CALCIUM STEARATE
SPECIFIED 18.4; DELIVERED 14.16;

<table>
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<tr>
<th>LOADING PRESSURE (KPSI)</th>
<th>DENSITY (GRAMS/CC) AVG</th>
<th>Δ% TMD</th>
<th>SHOCK STRENGTH, DBG AVG</th>
<th>Δ</th>
<th>Δ M</th>
<th>OUTPUT DENT (MILS)</th>
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<tbody>
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<td>1.4873 0.0041</td>
<td>90.744</td>
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<td>6.375 0.057</td>
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<td>1.5784 0.0021</td>
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<td>6.719 0.045</td>
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<td>1.5828 0.0034</td>
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<td>64</td>
<td>1.5887 0.0029</td>
<td>96.931</td>
<td>7.594 0.108</td>
<td>0.036</td>
<td>50.3</td>
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</tr>
</tbody>
</table>

*ΔM ESTIMATED

FIG.D-II LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X—NO.378.
APPENDIX D

COMPOSITION:

16.5% CALCIUM STEARATE

SPECIFIED 20.8; DELIVERED 16.55;

<table>
<thead>
<tr>
<th>LOADING PRESSURE (KPSI)</th>
<th>DENSITY (GRAMS/CC) AVG</th>
<th>% TMD SHOCK STRENGTH, DBG AVG</th>
<th>OUTPUT DENT (MILS)</th>
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<tbody>
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<td>4</td>
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<td>1.5845</td>
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<td>6.646 0.0025</td>
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<td>16</td>
<td>1.5936</td>
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<td>1.5662</td>
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<td>7.729 0.0026</td>
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* & M ESTIMATED

FIG. D-12 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X – NO. 381.

D-12
APPENDIX D

COMPOSITION:

18.70% CALCIUM STEARATE
SPECIFIED 23.3; DELIVERED 18.70;

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<th>LOADING PRESSURE (KPSI)</th>
<th>DENSITY (GRAMS/CC) AVG</th>
<th>% TMD AVG</th>
<th>SHOCK STRENGTH, DBG AVG</th>
<th>Δ</th>
<th>Δ M</th>
<th>OUTPUT DENT (MILS)</th>
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FIG.D-13 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X—NO. 384.
APPENDIX D

COMPOSITION:

21.49% CALCIUM STEARATE
SPECIFIED 26.0; DELIVERED 21.49;

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<th>LOADING PRESSURE (KPSI)</th>
<th>DENSITY (GRAMS/CC)</th>
<th>% TMD</th>
<th>SHOCK STRENGTH, DBG</th>
<th>OUTPUT DENT (MILS)</th>
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* & M ESTIMATED

FIG. D-14 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X—NO. 385.
APPENDIX D

COMPOSITION:

23.75% CALCIUM STEARATE
SPECIFIED 28.0; DELIVERED 23.75;

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<th>DENSITY (GRAMS/CC) AVG</th>
<th>% TMD AVG</th>
<th>SHOCK STRENGTH, DBG AVG</th>
<th>SHOCK STRENGTH, DBG Δ &amp; M</th>
<th>OUTPUT DENT (MILS)</th>
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* & M ESTIMATED

FIG. D-15 LOADING AND FIRING DATA FOR RDX CALCIUM STEARATE MIX X — NO. 386.
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Office of Chief of Engineers
Department of Army
Washington 25, D. C.
ENGNB
ENGEB

Commanding General
Picatinny Arsenal
Dover, New Jersey
ORDBB-THS
ORDBB-TJ1
ORDBB-TK3
ORDBB-TM1
ORDBB-TPI
ORDBB-TP2
ORDBB-TP3
ORDBB-TR2
ORDBB-TS1

Commanding Officer
Harry Diamond Laboratory
Connecticut Avenue & Van Ness St., N. W.
Washington 25, D. C.
Ordnance Development Laboratory
M. Lipnick (Code 005)

Commanding Officer
Office of Ordnance Research
Box CM
Duke Station
Durham, North Carolina

Commanding Officer
Rock Island Arsenal
Rock Island, Illinois

Commanding Officer
Chemical Corps
Chemical & Radiological Laboratory
Army Chemical Center, Md.

Commanding Officer
Engineer R&D Laboratory
U. S. Army
Ft. Belvoir, Virginia
Tech. Intelligence Branch

Commanding Officer
Fort Dietrick, Md.

Commanding General
U. S. Army Ordnance Ammunition Center
Joliet, Illinois
Commanding General
Aberdeen Proving Ground
Aberdeen, Md.
BRL

Commanding General
Frankford Arsenal
Philadelphia 37, Pennsylvania

Commanding Officer
Holston Ordnance Works
Kingsport, Tennessee

Commanding General
Redstone Arsenal
Huntsville, Alabama
Technical Library

Commander
Army Rocket & Guided Missile Agency
Redstone Arsenal, Alabama
ORDXR-RH

Commander
Ordnance Corps
Lake City Arsenal
Independence, Missouri
Industrial Engineering Division

Commanding General
White Sands Proving Ground
White Sands, New Mexico

Chief of Staff
U. S. Air Force
Washington 25, D. C.
AFORD-AR

Wright Air Development Division
Wright-Patterson Air Force Base, Ohio
WWAD

Headquarters Air Proving Ground Center
U. S. Air Force, ARDC
Eglin Air Force Base, Florida
PGTRI, Technical Library

Commander
Air Research & Development Command
Andrews Air Force Base
Washington 25, D. C.
Commander
Rome Air Development Center
Griffis Air Force Base
Rome, New York
1

Commander
Holloman Air Development Center
Alamagordo, New Mexico
1

Commanding Officer
Air Force Missile Test Center
Patrick Air Force Base, Florida
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Commander
Air Force Cambridge Research Center
L. G. Hanscom Field
Bedford, Massachusetts
1

Commander
Hill Air Force Base, Utah
OGAMA
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Hanscom Air Force Base
Massachusetts
APCCDD
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Capt. Long
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Defense Documentation Center
Arlington Hall Station
Arlington, Virginia
TIPDR
10

Office of Technical Services
Department of Commerce
Washington 25, D. C.
100

Atomic Energy Commission
Washington 25, D. C.
DMA
1

Chief
Defense Atomic Support Agency
Washington 25, D. C.
1

Director
U. S. Bureau of Mines
Division of Explosive Technology
4800 Forbes Street
Pittsburgh 13, Pennsylvania
1

Director, USAF Project RAND
(Via USAF Liaison Office)
The Rand Corp.
1700 Main Street
Santa Monica, California
1
Lawrence Radiation Laboratory
University of California
P. O. Box 808
Livermore, California
Technical Information Division
Director
Los Alamos Scientific Laboratory
P. O. Box 1663
Los Alamos, New Mexico
National Aeronautics & Space Administration
Headquarters
1520 H Street, N. W.
Washington 25, D. C.
National Aeronautics & Space Administration
Goddard Space Flight Center
Greenbelt, Maryland
Lewis Research Center, NASA
21000 Brookpark Road
Cleveland 35, Ohio
Library
Director
Johns Hopkins University
Applied Physics Laboratory
8621 Georgia Avenue
Silver Spring, Md.
Solid Propellants Agency
Sandia Corp.
P. O. Box 5400
Albuquerque, New Mexico
Sandia Corp.
P. O. Box 969
Livermore, California
Director
Waterways Experiment Station
Vicksburg, Tennessee
Atlantic Research Corporation
National Northern Division
P. O. Box 175
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Armour Research Foundation, Technology Center
Illinois Institute of Technology
10 West 35th Street
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Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 63-91)

1. Explosives - Sensitivity
2. Explosive trains - Safety
3. RDX/Calcium Stearate

The effects of composition and consolidating pressure on density, sensitivity, and output of RDX/Calcium-Stearate mixtures have been determined using the Small Scale Gap Test. These mixtures can be used to satisfy the immediate needs for explosives for VARIOMP measurement of weapon explosive train safety and reliability. But explosives systems should be developed wherein composition control to obtain specific sensitivity and output is less critical.