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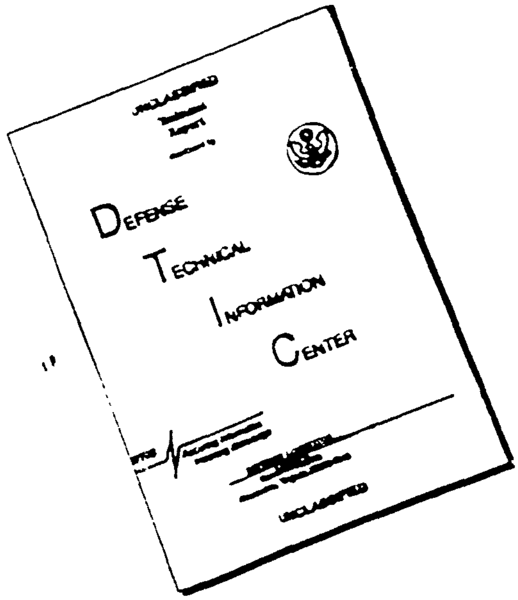

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SHOCK SENSITIVITY AND HAZARD CLASSIFICATION

20 APRIL 1965

NOL

UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAN

NOLTR 65-47

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Shock Sensitivity and Hazard Classification

By

I. Jaffe

ABSTRACT: The shock sensitivity of a fuel oil-ammonium nitrate mixture (nitrocarbonitrate) is less than zero cards on the large scale gap test, but 122 cards on the "extended" gap test. The latter test value results from the ease of initiating the reaction whereas the no-go on the standard test results from the very small damage caused by the detonation reaction. It is suggested that the hazard classification of nitrocarbonitrate be Class A or mass detonating because of the ease with which this reaction is initiated.

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This work was performed under Task RMMP 22149/F009-06-11. It is part of a continuing effort to correlate sensitivity tests and test results with the hazard characteristics and classification of explosives and propellants. This report discusses the usefulness of shock sensitivity tests to hazard classification.

R. E. ODENING
Captain, USN
Commander

Albert Lightbody
ALBERT LIGHTBODY
By direction

TABLE OF CONTENTS

ILLUSTRATIONS

FIGURES

Shock Sensitivity and Hazard Classification

INTRODUCTION

The Defense Department has established standard tests which determine the hazard classifications and hazard characteristics for ammunition and explosives (1). For the first time, minimum test criteria have been specified for solid propellants. Previously solid propellants were tested and treated as explosives, and, as such, the handling and use of these materials in the field were restricted. The new tests establish hazard classifications for shipping and storage and also determine certain hazard characteristics for solid propellants. This latter information is particularly useful in guiding the safe handling of a missile or device containing solid propellant in the field.

The present instructions (1) calls for a four phase program to be run from the inception of the propellant in the laboratory to the completed missile. However, the proposed revision of the tests to be adopted in the near future calls for only three phases. These are:

Phase I - The tests are made to determine the hazard classification of the solid propellant in the laboratory stage. Tests are made on small samples mainly to determine the Interstate Commerce Commission (ICC) classification for shipment.

Phase II - These tests are made on larger samples, from a few pounds to the full scale device, and the results are used to determine ICC and Military classifications. The latter is a classification which is used throughout the Defense Department.

Phase III - The tests are made on the completed, assembled system and the results are used for ICC and Military classification as well as to establish any specific hazards peculiar to the system.

The Laboratory is one of the work groups which developed the criteria for the required safety tests (1). Specifically, it was responsible for the development of the shock sensitivity test (card gap test) used in Phase II. This test is essentially the same as the NOL shock sensitivity test. The main exception is the use of a pentolite donor instead of the tetryl donor. Pentolite is a somewhat stronger booster and is easier to obtain commercially than tetryl.

A 50% probability point of 70 cards w^ chosen as the boundary between the classification of mater ials for which the hazard is chiefly fire hazards and mass detonation, respectively (1). If a propellant detonates with a 50% point gap below 70 cards its chief hazard is considered to be combustion rather than detonation; seventy cards or above, its chief hazard is considered to be a mass detonation. The gap equivalent of 1.78 cm (0.70 inches) was an arbitrary choice based upon the available results of shock sensitivity tests on solid propellants and the experience with these materials in the field.

To obtain a more realistic figure, it was suggested that a series of materials known as "nitrocarbonitrates" be shock tested. These materials are classified by the ICC (Bureau of Explosives) as fire hazards; however, they are considered by the Bureau of Explosives to be quite close to the materials classified as detonation hazards. It was hoped that the results of these shock sensitivity tests would give some proper guidance for the choice of a more realistic figure for classification in the card gap test, Phase II.

EXPERIMENTAL

"Nitrocarbonitrates" are essentially ammonium nitrate to which some fuel (coal, oil) has been added. The material tested, HP-61*, contains a major portion of ammonium nitrate and small amounts of coal and "hydrocarbon oil". The material is shipped in paper sacks, has a dark greyish color and a consistency of coarse sand.

Twenty of the standardized steel tubes used in the NOL gap test were sealed off at one end by cementing a cellulose acetate card to the bottom of the tube. The tubes were carefully weighed and measured to determine their volume and mass before a given mass of the "nitrocarbonitrate" was poured into them. The density of the charges was adjusted to 0.8 g/cc, which is the manufactured density and the working density in the field.

Both the NOL standard gap test and the extended gap test have been described in the literature in detail (2, 3, 4). Figures 1 and 2 are schematic drawings showing the important features of the tests. In both instances a standard donor composed of two pressed graphited tetryl pellets ($\rho = 1.51 \pm 0.01$ g/cc) is initiated by a No. 6 detonator**. A variable gap

* Manufactured by the Hercules Powder Co., Kenvil, N. J.
** Manufactured by Olin Mathieson

is obtained with cellulose acetate cards each 0.025 cm (0.01 inch) thick and 5.08 cm (2.00 inches) in diameter and polymethylmethacrylate (PMMA)* discs equivalent to 50 (0.5 inches) and 100 (1.0 inch) cards. Thus it is possible to obtain any thickness of gap in increments of 0.025 cm (0.01 inch) by using the cards, discs, or a combination of both. It had been determined that cellulose acetate and PMMA discs may be used interchangeably (3).

The acceptor is cast, pressed or in this instance poured into a standard cold drawn, mild steel, seamless pipe. The witness plate is made of mild steel, 0.95 cm (3/8 inch) thick and 15.2 cm (4 inches) square. After a test, a plate which is retrieved with a hole in it is taken as evidence of a "go" in this go/no-go test.

The extended gap test differs from the NOL standard test in that an explosive (rather than a steel plate) witness is used (Fig. 2). The steel witness plate is used here to judge whether the explosive witness detonated or not. With an explosive witness it is possible to test materials which are shock sensitive but which do not develop a detonation pressure large enough to punch a hole in the steel witness plate. In the present instance, cast TNT was used as the explosive witness.

RESULTS

The standard NOL gap tests made with HP-61 gave a no-go. The witness plate for the test, made at a gap of one card, contained a deep, derby-shaped bulge, but no hole, which is the criterion for a go (Figure 3). Table 1 contains the results of tests made with gaps ranging up to 150 cards. In all instances the plates were bulged as in Figure 4. This indicated that a strong chemical reaction occurred (possibly a detonation) whose reaction pressure was below that required to produce a hole in the witness plate. Table 2 contains the results of the extended gap test. The 50% point of HP-61 was determined as 121 cards.

DISCUSSION

By the NOL extended gap test, HP-61 with a 50% gap of 121 cards (119 cards for a pentolite donor) falls in the class of propellants for which the chief hazard is mass detonation (1). By the Bureau of Explosives test IB-1 (1), however,

* Usually Plexiglas manufactured by Rohm and Haas

HP-61 is considered a material for which the chief hazard is combustion. These contradictory classifications of the same material arise for two reasons:

(1) The NOL test result is determined principally by the shock sensitivity of the material, no matter how weak or how strong the reaction initiated by the shock. The Bureau of Explosives test, on the other hand, measures chiefly the damage caused by whatever reaction is initiated. A two inch cube of the material is placed on a lead cylinder (1.5 in. diam x 4 in. length) and initiated by a blasting cap; damage to the lead cylinder is the test result. Ease of initiation and amount of damage caused by the reaction initiated are not necessarily related. In the case of organic H.E., detonations do cause large amounts of damage, but for composite explosives, e.g., HP-61, this is obviously not always so.

(2) The limiting gap value of 70 cards was selected for non-porous propellants of much higher impedance than the HP-61, e.g., of densities 1.7 g/cc and greater rather than 0.8 g/cc. For this reason, granular and non-porous materials cannot be judged on the same scale; this matter was discussed at some length in Ref. (4). A gap of 121 cards for HP-61 indicates a much lower pressure transmitted to a sample of 0.8 g/cc than to one of 1.7 g/cc. Hence a valid comparison can only be made in terms of pressures transmitted to the two test samples, not in terms of the 50% gap thickness measured in the two cases. HP-61 is much more sensitive than a voidless propellant which has the same 50% gap thickness of 121 cards.

From the standpoint of hazards, both factors: ease of initiating the reaction and the damage which the reaction can cause, once it is initiated, are important. It is necessary to design tests to measure such factors quantitatively (and, if possible, separately), and then assign them weighting according to their respective roles in hazardous situations. With sufficient exact knowledge, ambiguities in classification such as that illustrated with HP-61 may be avoided.

Inasmuch as detonation of HP-61 will cause a large amount of damage (even though less than an equal amount of TNT), it should be classified as a mass detonating material in accord with its shock sensitivity.

REFERENCES

1. Explosive Hazard Classification Procedure, BUWEPINST 8020.

2. D. Price and I. Jaffe, ARS Journal, 31, 595-599 (1961).

3. I. Jaffe, R. Beauregard, and A. Amster, ARS Journal, 32, 22-25 (1962).

4. D. Price and I. Jaffe, AIAA Journal, 1, 389-394 (1963).

TABLE 1 - Results of the Standard Gap Test

Shot No.	Cards	Result*
1	1	±
2	60	±
3	115	±
4	122	±
5	150	±

* + - go

 - - no-go

 ± - no-go, but plate contains a depression (see Fig. 4)

Tetryl lot No. 1878-125

TABLE 2 - Results of the Extended Gap Test*

Shot No.	Cards	Result
1	1	+
2	1	+
3	51	+
4	75	+
5	150	-
6	110	+
7	130	-
8	120	+
9	125	-
10	123	-
11	121	+
12	122	-
50% Point	121 Cards	

* Witness: cast TNT
 Tetryl lot: 1878-125

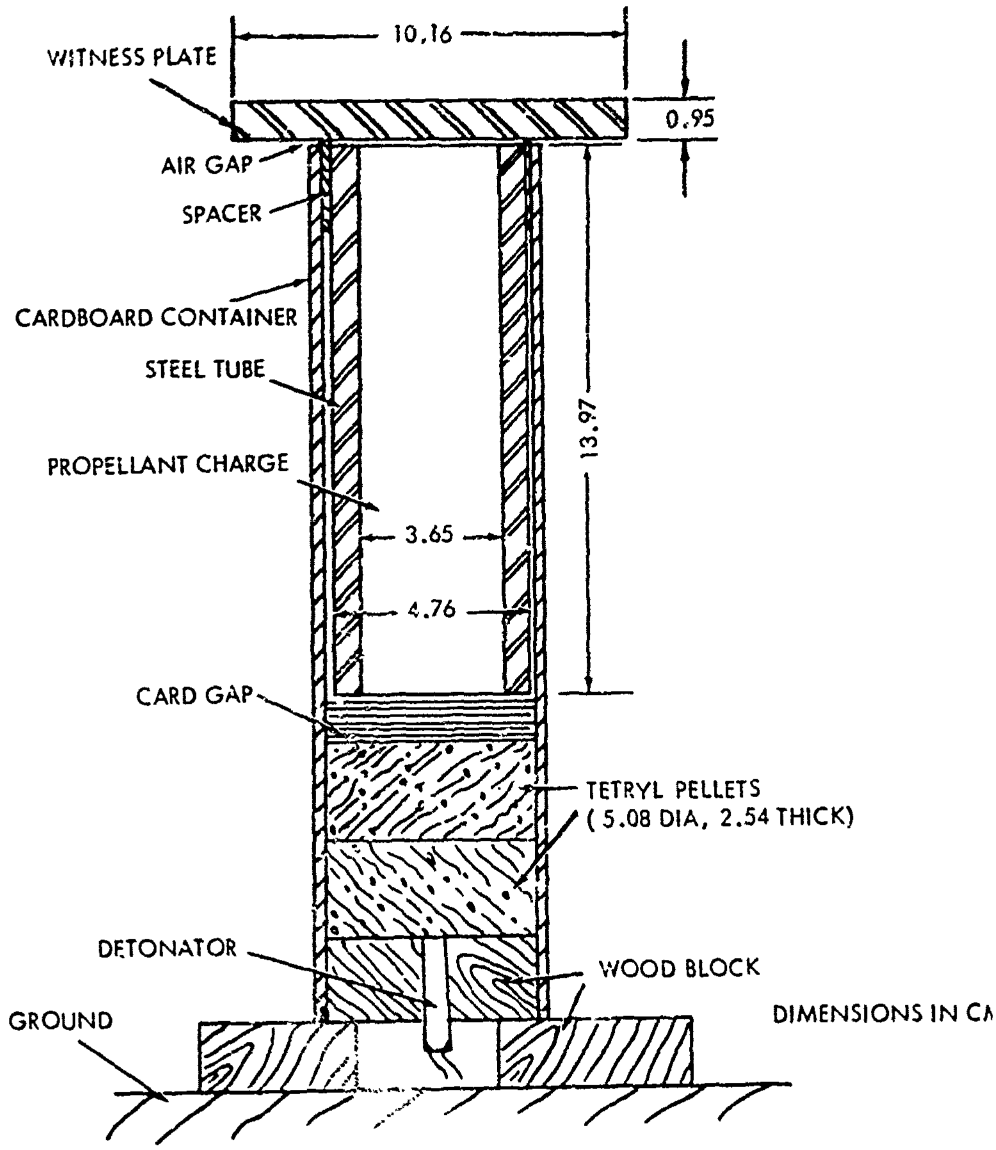

FIG. 1 GAP TEST ASSEMBLY

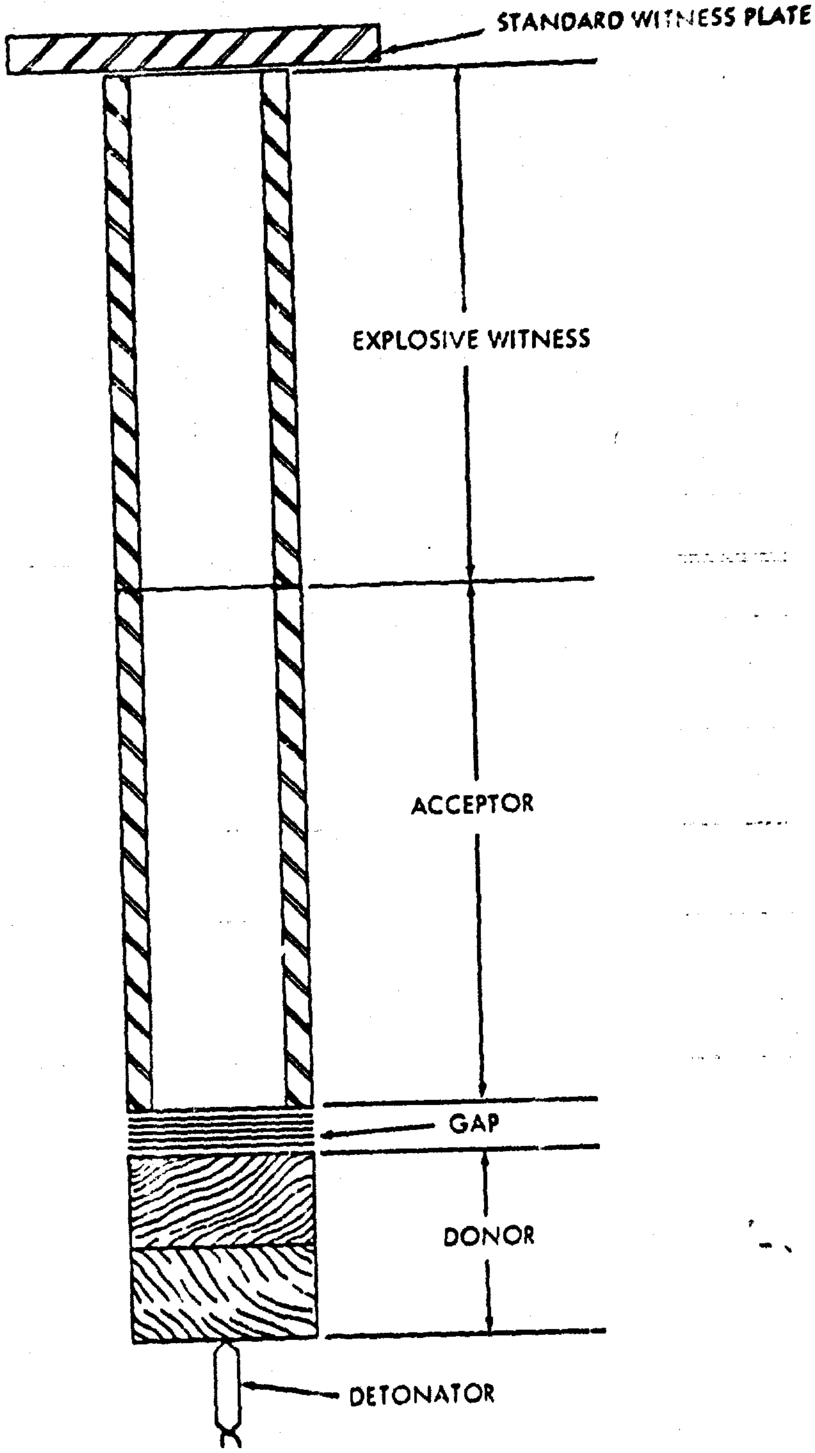

FIG. 2 THE EXTENDED GAP TEST

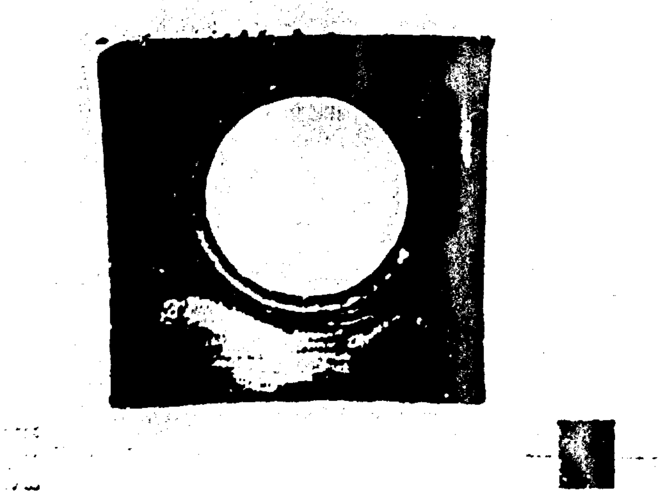

FIG. 3 A WITNESS PLATE OBTAINED AS THE RESULT OF A DETONATION [illegible]

FIG. 4 FRONT AND SIDE [illegible] PLATE OBTAINED AS THE [illegible]
OF A [illegible]

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