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EXTRUDABLE EXPLOSIVES

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DEVELOPMENT DIVISION

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MASTER

For
Normal Process Development
Endeavor No. 202

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The purpose of this project is to develop a high temperature extrudable explosive.

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Acct. No. 22-2-44-01-202

Section C

EXTRUDABLE EXPLOSIVES

ABSTRACT

Several extrudable HE formulations using, principally, HNAB as the explosive component were examined in efforts to develop an extrudable composition more temperature-resistant than Extex. It is shown that extrudability is dependent upon particle character, wetting of the binder compound, roll-milling technique and the addition of fine metallic oxides to improve flow properties, while detonability is dependent upon explosive concentration, a hard cure, and the shock parameters of the confining media.

DISCUSSION

Previous work(*1*) had indicated that a binder material with thermal properties equal to or better than the HE component was required to prevent migration or decomposition during the curing cycle, a curing temperature $\geq$ 100 C was desirable to effect high hardness of cure, and an optimized temperature-resistant confinement material affording shock support was required to decrease failure diameter of the extrusions.

Using the above guidelines, the following experimental approach was used: temperature resistant binder compounds such as Acryloids and Dexsil resins(*2*) were obtained to use in the formulations, a small curing oven was constructed for remotely heating the samples; and work was begun to devise an epoxy-base, temperature-resistant test fixture for containment of the extruded samples.

Sixteen 100g sample HNAB/binder compositions were formulated; however, only six of these were deemed suitable for further tests. In each case the selected compositions were adjusted for the maximum HE content which would allow extrusion, or in one case, compaction into tracks as small as 0.030-inch diameter and at least 1 inch in length. A cursory examination was made of each formulation for roll-milling, extrusion and detonation properties. Detonation tests included firing 1/4-inch diameter cured pellets in the standard gap sensitivity test with zero gaps and steel witness plates then selecting the most promising samples for failure diameter determinations. These samples were extruded into various sized tracks in aluminum test blocks explosively driven by modified P-16 PWL's as shown in Fig. 1. Outputs of the tracks were viewed by a streak camera with the slit plate aligned on the centerline of the holes using a writing speed of approximately 1 mm/μsec.

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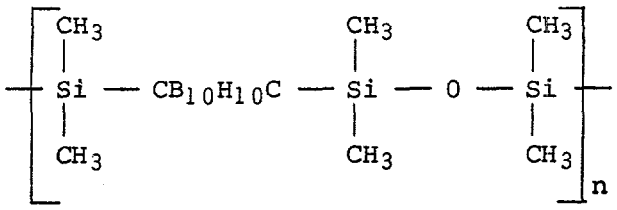
(1) *Evaluation of HNAB in an Extrudable Explosive, N. O. Rhoton and T. W. Warren, 14th Meeting of JOWOG-9.*

(2) *Rohm and Haas Tech. Letter, October 22, 1965, and Olin Chemical Newsletter No. 1, December 8, 1967.*

The results of these tests are given in Table I.

The most promising composition was Batch No. 01-127-02 which contained 20% Dexsil 202 liquid polymer and 2% pure red iron oxide (Fe_2O_3) with a surface area of 5.1 m^2/g, 91.7 wt percent 0.5μ particle size or less(3), the balance HNAB.

The chemical structure of the polymer binder used is as follows:



The correct name of this structure is poly-1-dimethylsilyl-7-(bisdimethylsiloxyl)-1,7-dicarboxydecaborane. This is, in the series of these structures, the silicon-boron polymer and the vendor's trade name is Dexsil 202.

The detonation velocities observed for the compositions during failure diameter tests were approximately 5 mm/μsec (± 5%), suggesting strong shock support from the aluminum confinement. This is usually not desirable for most applications of extrudable explosives due to preshock or cross propagation; therefore, efforts were directed toward developing a high temperature fixture, preferably exhibiting low shock propagation (implying a low density), in which to form the tracks for extrusion.

The first such fixture tested was press-formed from a metallized epoxy containing a mixture of 54% aluminum oxide ground with Dexsil 202 and cured. A test was fired using this fixture extruded with composition No. 01-127-02 in a similar manner as the failure diameter tests with the exception that four equally spaced 0.125-inch diameter holes contained the extrusions because the fixture was difficult to drill. The HNAB composition failed to detonate in this fixture.

Other fixture formulations were made and fixture pressing dies were fabricated to pre-form the holes required for failure diameter tests-precluding drilling. The fixture compositions are given in Table II. Composition No. 01-174-02, previously described, has been the only one extruded and test fired thus far.

In order to cure the high temperature extrudable HE formulations as well as the higher temperature binders used to press fixtures it was necessary to construct an oven which could be operated remotely.

A curing furnace was set up from three foamed insulation fire bricks. This material was easily formed to provide a 1-1/2-inch by 4-inch heating chamber 7 inches long using two bricks. A third brick was cut to form the door. The whole was

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(3) C. K. Williams & Co. Tech Report, High Purity Iron Oxides.

Table I. Extrudable HNAB Compositions

PX Batch No.	Composition	Weight Percent	Physical Properties		Detonability
			Roll Mill	Extrudability	
01-127-01	HNAB[a]/Dexsil 202	80/20	Not Milled	Difficult, Separates when cured at 400 F	Failure - Pellet Test
01-127-02	HNAB[b]/Dexsil 202/ Fe_2O_3 (5098)	80/20/2	Good, oxide helps	Good, no separation when cured at 400 F	Apparent high order - Pellet Test, detonates in 0.052-in, dia. Al track, failed in 0.040 dia.
01-095-02	HNAB[a]/AT-71 Acrylic/G-50 Plasticizer	85/14.5/.5	Good, probably the best one	Smooth, but short, cures properly, not much elongation	Deflagration - Pellet Test, apparent detonation (weak output) in 0.052-in, dia. Al track
01-105-01A	HNAB[b]/Dexsil 202/ Flexol 380 plasticizer	88/10/2	Very good	Difficult, plastized but still short	Deflagration - Pellet Test, Apparent detonation (weak output) in 0.052-in, dia. Al track. Composition pressed into fixture holes with dowel pins.
01-103-02	HNAB[a]/AT-70 Acrylic/G-50 plasticizer	84/10/6	Dry, not enough plasticizer	Not extruded, too dry not well mixed	Deflagration - Pellet Test, Apparent detonation (weak output) in 0.052-in, dia. Al track
01-124-01	HNAB[a]/Dexsil 202/ Hercoflex 900 plasticizer	81/14/5	Rolls well has wetting agent	Will extrude, needs short cure	Very low order - Pellet test

[a] *Northrup Carolina HNAB Batch 43-11A*

[b] *Pantex HNAB Batch 0334-12-01*

Table II. Extruded Track Fixture Compositions

PX Batch No.	Composition	Weight Percent	Roll Mill	Treatment	Fixture Pressing
01-168-01	Dexsil/Cab-o-sil	60/40	Rolls well, use Cab-o-sil M-5	Cure at 600 F, grind and press	25,000 psi - 15 min, release 10 min, density 1.36-1.40
01-174-02	Dexsil/Al_2O_3	46/54	Alon (Cabot Al_2O_3), rolls well (hot)	Cure at 600 F, grind and press	25,000 psi - 15 min, release 10 min, density 1.51
01-175-01	Dexsil/boron nitride	46/-43/54	H.T.P. BN -5μ (Carborundum Co) roll mill hot	Cure at 600 F for 2-3 hrs, grind and press	25,000 psi - 12 min hold, release 10 min, density 1.8
01-197-02	Dexsil/Al_2O_3	46/54	Alon (Cabot AL_2O_3), roll mill hot	Cure at 600 F for 3 hrs grind and press, best to grind cold at -40 C	Square Die 1" x 1" x 1.6", 17,500 psi - 10 min hold, 10 min release

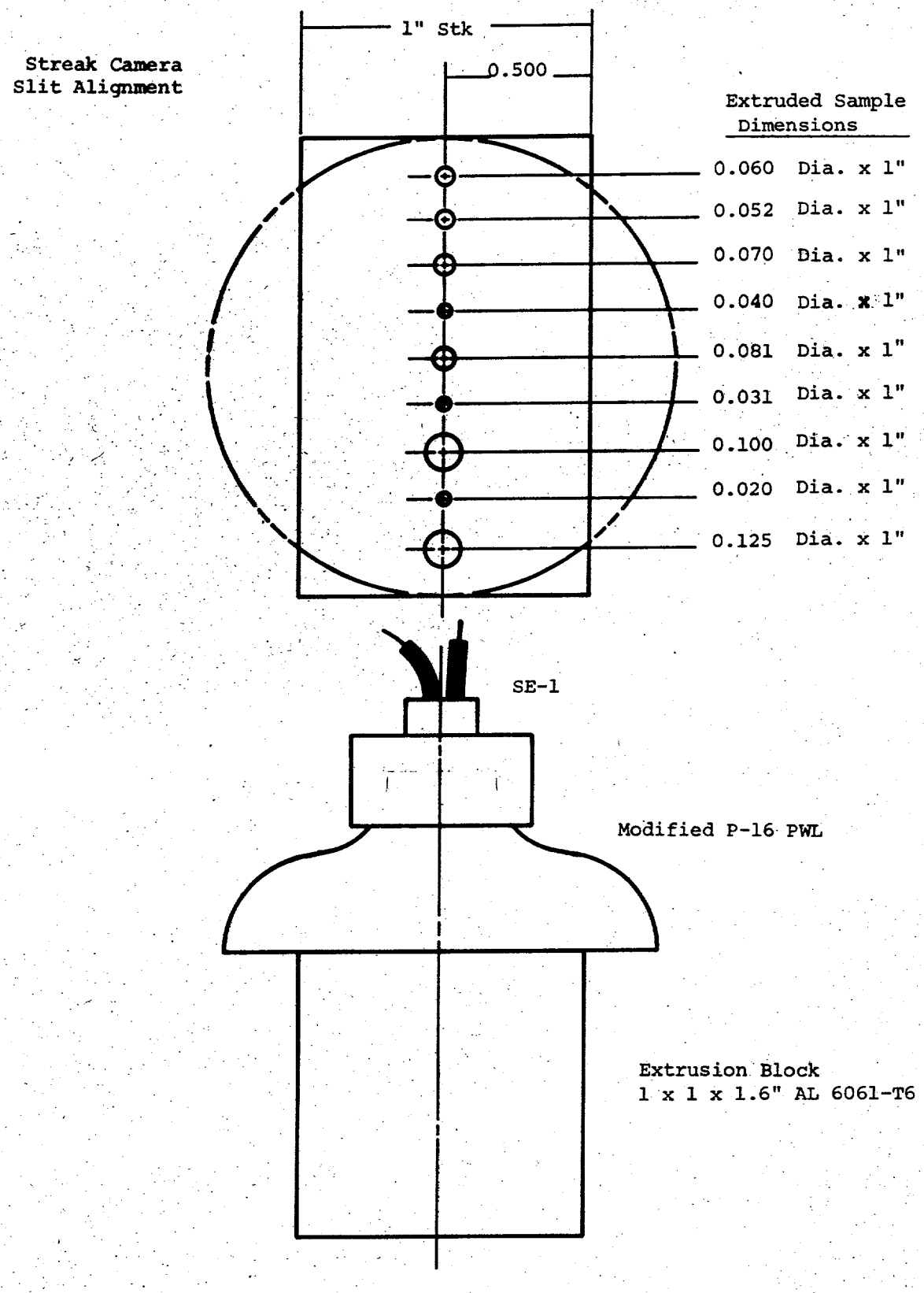

Fig. 1. Failure Diameter Test Fixture

mounted on a 750-watt porcelain adjustable hot plate on three layers of asbestos paper. The bottom and walls of the brick furnace interior were lined with aluminum foil. Two glass thermometers were placed in the furnace chamber through holes in the roof; one to give the chamber temperature and the other to rest directly on the sample. The range of the furnace was from 20 to 350 C. A temperature of 200 C ± 5 was used to cure all compositions containing HNAB. From DTA data, 204 C was selected as a conservatively safe curing temperature for compositions that contained HNAB. A temperature of 310 C ± 5 (600 F) was used as a curing temperature for the high temperature binders alone (i.e., with no HE).

The curing processes of the extrudable HNAB formulations were complicated by the fact that recommended cure temperatures for the binders used were much higher than the decomposition temperature of HNAB. The relatively low cure temperatures thus required did not produce substantially high hardness of cured samples, as measured by durometer, deemed necessary to improve the shock sensitivity of the explosive.

An explosive powder with a higher decomposition temperature, CEP (Batch 4-10, 4200 cm^2/g) was tested in a formulation with Dexsil 202, a 90/10 HE to binder wt percent, to increase the cure temperature to 230 C (CEP decomposes near 270 C and exhibits no endotherm at $\sim$ 220 C as does HNAB, by comparable DTA analyses). Although this composition yielded a higher HE concentration, roll-milled and extruded easily, it failed to deflagrate in both the gap sensitivity test and the failure diameter tests—regardless of the higher durometer cure.

FUTURE WORK; COMMENTS; CONCLUSIONS

Of the formulations tested thus far none have closely approached Extex firing performance, although all of them are more resistant to high temperatures. Perhaps one or two of these formulations could be further refined with some success. However, it has been suggested that other shock-sensitive explosives should be explored first, especially sublimed RDX, colloid milled HMX, trinitromesitylene and DTF. Other high temperature binders such as monothane (one component polyurethane) and some of the new metallic epoxies are worthy of investigation.

The most time-consuming and confounding operation of the formulation procedure presently used is roll milling—a trial and error series of roller spacings and temperature adjustments to suit each composition. Coarse powders tended to mill and blend with the binders better than fine powders. A more precise and simpler method of blending the explosive and binder components should be sought.

Felt metal, although very porous, has been extruded with Extex in diameters to 0.080 inch for other projects and appears to be a good shock-attenuating material for use as a track fixture to test temperature-resistant extrudable compositions in future work.