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AN IMPROVED INFRARED FLARE COMPOSITION

(U)

by
E. C. Julian
and
E. A. Allen
Propulsion Development Department

ABSTRACT. An improved infrared (IR) flare composition containing Teflon, Viton A, and magnesium is described. This improved composition has excellent tensile strength, IR output superior to previous compositions, and decreased electrostatic sensitivity. A compositional diagram showing that a systematic variation in flare burning time is definitely related to Teflon particle size is presented as a guide for planning future flare compositions. It was found that flare burning times and IR output at ground level or at simulated high altitude may be used as criteria for acceptance in specific applications. Investigations are being conducted to improve the performance characteristics of this flare composition. (UNCLASSIFIED)

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FOREWORD

A search for more efficient infrared (IR) pyrotechnic flare formulations has been undertaken by the three services of the Department of Defense and their contractors. This report describes a new flare composition developed at the Naval Ordnance Test Station (NOTS). The composition and processing techniques are under patent application by NOTS.

The new flare formulations have not only greater efficiency, but also have less electrostatic sensitivity than the NOTS standard IR flare composition. The improved strength of extruded products holds great promise for caseless flares.

The data contained in this report, based on a limited number of tests, are subject to revision. The report has been reviewed for technical accuracy by F. G. Crescenzo. The authors gratefully acknowledge the assistance of J. W. French for flare-inhibiting studies.

This development and its supporting research were performed under the following Bureau of Naval Weapons Task Assignments: RMMO-32-314/216-1/F008-17-002 (FY61), RAV33N-003/216-1/F010-02-002 (FY61), RMMO-7A-040/216-7/F008-17-002 (FY61), RMMO-32-024/216-1/F008-17-002 (FY62), RAV33W-009/216-1/F010-02-003 (FY62), and RAV33N-010/216-1/F010-02-002 (FY62).

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INTRODUCTION

For several applications, a flare is needed with a large infrared (IR) radiation yield. While the NOTS standard IR flare composition has offered a substantial improvement over previous compositions, a number of shortcomings prompted the development of the improved composition described herein. These shortcomings include low tensile strength and a considerable hazard because of a 50%-point electrostatic sensitivity of 0.76 joule. The improved composition has less electrostatic sensitivity; at 12.5 joules, it showed no fires in 10 successive tests; the improved composition can be easily extruded or compression molded; and extruded forms have tensile strengths and elongation that withstand forces and vibrations encountered in the various applications. These forms are also easily machined. Tracking flares that are attached to rocket sleds are subjected to intense vibrations during the sled run. Conventional flares have invariably been broken off by these vibrations, but the flares extruded from the improved composition have successfully undergone several sled runs.

STANDARD IR FLARE COMPOSITION

The NOTS standard IR flare composition consists of the following percentages of ingredients:

Magnesium, granulation 16	54
Teflon, No. 1, 600 microns ...	30
Kel-F wax, No. 40	16

Extrusion studies made on the above composition indicate that the tensile strength is quite low and the density is only about 90% of theoretical. Flares of this composition are usually made by compression molding; long flare rods are made by molding in increments.

IMPROVED IR FLARE COMPOSITION

In 1959, it was discovered that a combination of Teflon and Viton A, produced by a shock-gel process, could be easily extruded at temperatures ranging from 150 to 225°F in conventional double-base extrusion presses. The improved IR flare composition consists of the following percentages of ingredients:

Magnesium, granulation 16	54
Teflon, No. 7, 35 microns.......	30
Viton A	16

The shock-gel process may be described as follows: Viton A, a copolymer of vinylidene fluoride and hexafluoropropylene, is dissolved in acetone to form a solution ranging from 8 to 20% solids. The required quantities of magnesium and Teflon are stirred into the appropriate quantity of Viton A solution. This slurry is quickly added to a large volume of rapidly agitating hexane. By this treatment, all the material is precipitated in a granular form. After one or more washes with additional hexane, the material is collected and dried. While drying, the material is usually passed through a brass screen with 1/4-inch openings.

The granular material is then heated to 190°F, placed in the barrel of an extrusion press (heated to 225°F), and extruded through the die. The extrusion pressures and flow rates are dependent upon (1) the total binder content, (2) the Viton A-Teflon ratio, (3) the particle size (and particle shape) of the filler, (4) the ratio of die area to barrel area in cross section, and (5) the shape and design of the die itself.

After the extrusion is completed, the material may be machined into desired lengths or shapes as required.

Flare-inhibiting studies resulted in the development of a surface treatment of the extruded flare with hydrochloric acid before coating it with the inhibitor to improve its adhesion.

OPTIMIZATION STUDIES

One of the parameters considered involves the use of granulations of magnesium at several levels. This program represents the preliminary phase of an experiment designed to optimize the composition. The types of magnesium considered were granulations 15, 16, and 17. These were incorporated at the 54% level for combinations with Teflon and Kel-F wax and at the 64% level for two compositions, the first with 36% Viton A and the second with 20% Teflon and 16% Viton A. These ranges were chosen to detect significant increases in performance quickly, using an all-Viton A binder and a higher level of magnesium.

The flare compositions were tested for IR output in the following manner: 6-inch to 10-inch lengths of 1-inch-diameter rods were inhibited, fitted with an igniter assembly, and mounted vertically so that the radiometer sensor was directed normal to the flame at a suitable distance. Pressed charges were prepared of several increments in 1.0-inch-diameter aluminum tubing with a 0.035-inch wall and a length of 6 inches at 7,500 psi.

Granulation 16 magnesium appears to yield from 40 to 1800% more w/sterad than the compositions with either granulation 15 or 17 magnesium. The maximum radiation in w/sterad, 2,672, was obtained from Pilot Lot (PL) 6299 (Table 1). In PL6294, containing granulation 15 magnesium,

TABLE 1. IR OUTPUT FOR SEVERAL FLARE COMPOSITIONS

Compositions, %						Type or lot	IR output		Average duration, sec
Magnesium			Teflon	Viton A	Kel-F wax		j/g	w/sterad	
Gran. 15	Gran. 16	Gran. 17							
54	....	....	30	....	16	Standard	190	1,019	18.7
64	....	....	....	36	....	PL6294	317	853	24.0
64	....	....	20	16	....	PL6295	227	224	89.0
....	54	....	30	....	16	Standard	142	1,653	8.1
....	64	....	....	36	....	PL6296	220	2,341	8.0
....	64	....	20	16	....	PL6299	223	2,672	7.7
....	....	54	30	....	16	Standard	195	608	32
....	....	64	....	36	....	PL6297	102	176	51
....	....	64	20	16	....	PL6298	198	168	103

the maximum output of 317 j/g was obtained. Since the average duration (total burn time) for the flare is significant for various applications, these values are also presented.

In Fig. 1, a compositional diagram is shown for the three ingredients, magnesium, Teflon, and Viton A. The area of low IR output is on the left, the limit of extrudability on the right and above, and the area of low strength on the bottom. The compositions, indicated by small circles, are being evaluated. These lots constitute Phase II of the designed experiment. Assessment of output data on these lots should undoubtedly lead to an optimization.

It had been reported that the use of Teflon No. 1, with an average particle size of 600 microns, in the flare composition increased the burning rate when such flares were molded. Phase III of the designed experiment investigated the possibility that coarse Teflon would modify the performance. The result is shown graphically in Fig. 2.where the burning times of wedge-shaped flares are shown in contours on the compositional diagram for three grades of Teflon. The composition contains 54% magnesium, granulation 16, and 16% Viton A. Teflons No. 7, 5, and 1 are used in the compositions at the total level of 30%. The average particle sizes are 35, 300, and 600 microns, respectively. A systematic variation in flare burning time is definitely related to the distribution of the Teflon particle size. This diagram is a guide for the planning of future flare compositions.

In Table 2 are tabulated the lot number, the composition, the burning time for the flare as well as burning rate in sec/in., strand burning rates, and calculated flare burning times based on two methods of strand inhibiting. These strand-burning data indicate that, with flare compositions that are rich in fuel, possible interactions between the inhibitor material and the burning flare material might show large differences in rate when compared to burning uninhibited flares. Flare burning times together with IR-output measurements either at ground level or at simulated high altitude may be used as criteria for acceptance in specific applications.

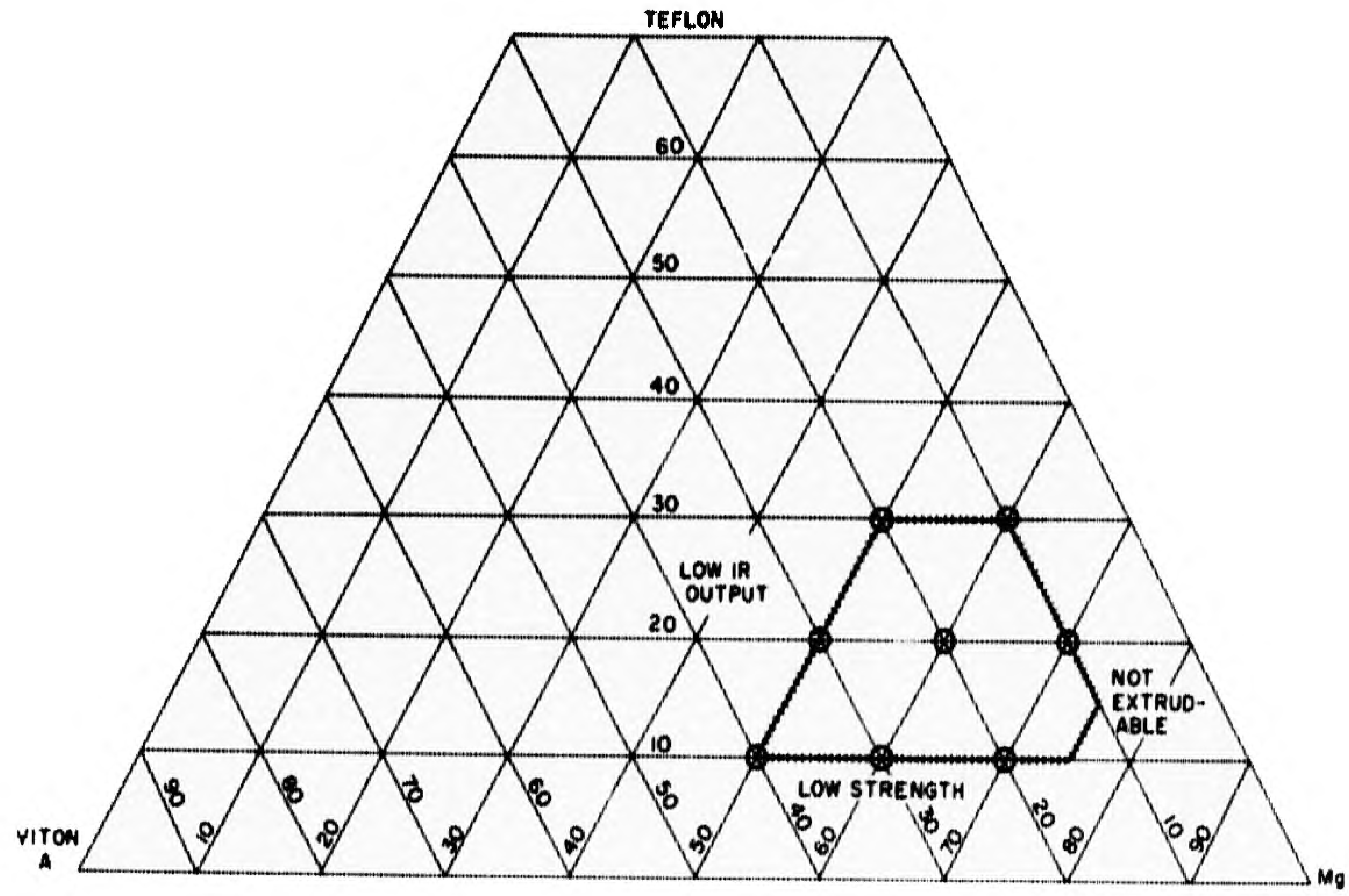

FIG. 1. Compositional Diagram for Improved IR Flare Composition.

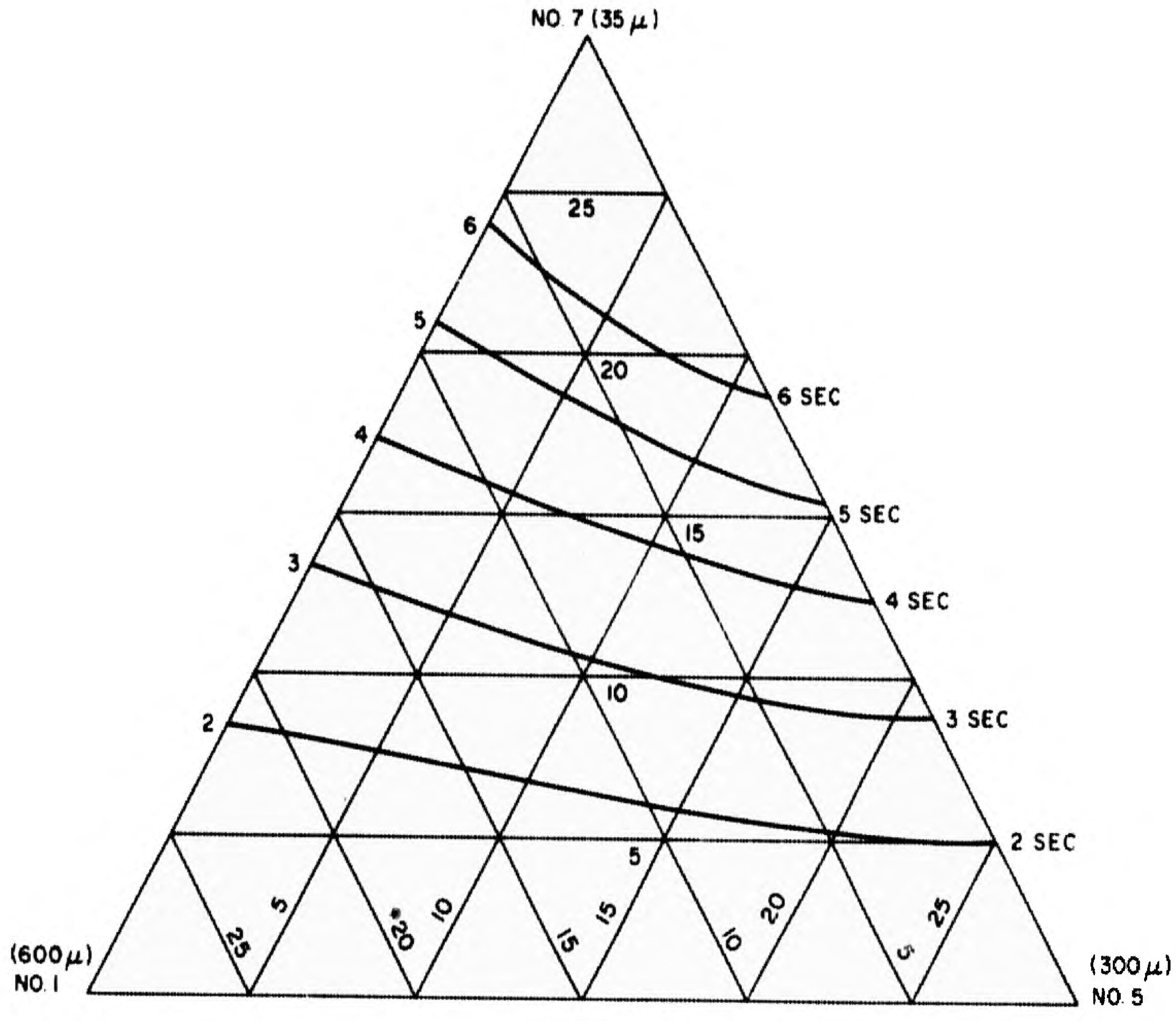

FIG. 2. Burning Time for Three Grades of Teflon at the 30% Level for Improved IR Flare Composition.

TABLE 2. BURNING TIMES AND BURNING RATES FOR SEVERAL IR FLARE COMPOSITIONS

Lot	Teflon[a], %			Flares			Strands			
				Burn time		Calcd. rate[b]	Viton lacquer[c]		Viton cement[e]	
	No. 7	No. 5	No. 1	Total	Sec/in.		Calcd. burn time[d]	Rate, sec/in.	Calcd. burn time	Rate, sec/in.
PL6278	22.5	7.5	......	7.5	15.0	0.067	3.9	7.7	5.0	10.0
PL6279	15.0	15.0	......	3.0	6.0	.167	3.4	6.8	5.9	11.8
PL6280	7.5	22.5	......	2.6	5.2	.192	3.1	6.3	6.1	12.2
PL6281	22.5	......	7.5	5.5	11.0	.091	3.2	6.5	6.9	13.9
PL6282	15.0	......	15.0	3.4	6.8	.147	3.1	6.2	......	......
PL6283	7.5	......	22.5	1.9	3.8	.263	2.8	5.7	5.0	10.0
PL6287	5.0	12.5	12.5	1.8	3.6	.278	3.1	6.3	4.9	9.8
PL6288	10.0	10.0	10.0	2.5	5.0	.200	3.2	6.3	5.0	10.0
PL6289	15.0	7.5	7.5	4.2	8.4	.119	2.6	5.1	5.7	11.5
PL6290	20.0	5.0	5.0	5.6	11.2	0.089	2:6	5.2	6.3	12.7

[a] The remainder of each composition consists of 16% Viton A and 54% magnesium, gran. 16.

[b] Calculated burning rate based on a maximum web thickness of 0.5 inch.

[c] Inhibited with Viton A in acetone.

[d] Calculated burning time of wedge based on a maximum web thickness of 0.5 inch, based on strand burning rate.

[e] Inhibited with RTV C-328 cement.

PHYSICAL CHARACTERISTICS OF THE IMPROVED IR FLARE COMPOSITION

Table 3 shows the maximum tensile strength, elongation at rupture, and modulus of elasticity of the improved IR flare composition when extruded into 1.0-inch-diameter rod. The rods were machined into cylindrical tensile specimens.

CONCLUSIONS

A systematic variation in flare burning time is definitely related to the distribution of Teflon particle size.

TABLE 3. PHYSICAL PROPERTIES OF THE IMPROVED FLARE COMPOSITION

Temp., °F	Tensile strength at maximum, psi	Elongation at rupture, %	Modulus of elasticity
-65	8,505	1.4	493.6
77	796	109.4	15.3
160	369	72.4	5.7

Flare burning times together with IR-output measurements either at ground level or at simulated high altitude may be used as criteria for acceptance in specific applications.

Strand burning-rate data indicate that, in the case of flare compositions that are rich in fuel, possible interactions between the inhibitor material and the burning flare material might show large differences in burning rate when compared to the strand burning rate of uninhibited flares.

Further refinements of the improved IR flare composition are being investigated.

RECOMMENDATIONS

Performance comparisons of the following combinations in the composition should be conducted:

1. Kel-F elastomers in place of Viton A
2. Combinations of Kel-F elastomers and Viton A
3. Graphite nuclei systems, such as anthracene and phenanthrene, reported by the Air Force to enhance IR yield
4. Various fillers to increase output and efficiency

The shock-gel process should be applied to visible flare formulations for extrudability, increased luminosity, and increased shelf life.

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