WORKING PARTY ON THE SUPPLY OF PROPELLANTS FOR ROCKETS

MINUTES.

Ninth Meeting of the Working Party held in Room S5A, Shell Mex House on the 29th October, 1954, at 2.30.p.m.

Present:	Mr. F.G. Willson,	A.D.M.X.R.D.(X).	(Chairman).
	Mr. F.C. Everett,	Secretary, E.D.P.C.	
	Mr. A.W. Leonard,	X.C.P.A.	
	Mr. J.L. Litton,	A.D.E.	
	Dr. K.D. Errington,	A.D./G.W.P.	
	Mrs. I. Peers,	G.W.P.	
	Dr. W.G. Williams,	E.R.D.E.	
	Mr. A. Brewin,	E.R.D.E.	
	Mr. P.R. Freeman.	E.R.D.E.	(Secretary)

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33. Chairman's Opening Remarks.

The Chairman opened the meeting by saying that it had been called to discuss the draft of the Second Report of the Working Party, which had been circulated to memebrs. This draft had been written almost entirely by the Chairman but, of course, it could not be published until the approval of the Working Party was obtained.

Before dealing with the report in detail, the minutes of the Eighth Meeting were taken.

34. Minutes of the Eighth Meeting and Matters Arising.

The Minutes of the Eighth Meeting were accepted.

Action 17. This action, on Mr. A.W. Leonard, had not been carried out owing to uncertainty over wartime requirements.

Action 18. Dr. Errington said that tables of propellant requirements of the G.W. Directorate had been forwarded to the Chairman but one or two alterations were now required. He also pointed out two mistakes in the modified tables used in the draft report; these were rectified. Dr. Errington emphasised the secret nature of the data he had supplied and stressed that it was particularly important to ensure that the figures did not become known to G.W. contractors, whether or not their security clearance was sufficient.

Actions 28 and 29 had been carried out by A.D./G.W.P. and the Secretary respectively.

35. Draft of Second Report of the Working Party.

Mr. Leonard queried the war-time requirement figures given in Table 3. He said that X.C.P. had been unable to obtain any war-time figures at all.

The Chairman replied that a number of authorities had given war-time requirement figures and that where these had not been obtained intelligent guesses had been made.

Mr. Leonard also queried the figure of 250,000 rounds given as the

/annual

annual requirement for the 3-inch Air to Ground Rocket. The latest figure obtained by X.C.P. was for only 70,000 rounds.

During discussion it transpired that Mr. Leonard's figure was an Air Force requirement only; the Navy had also stated a requirement for about 120,000 rounds per annum.

Mr. Litton pointed out that the propellant for the 3-inch Rocket is SU/K. The F.488 type propellant will be used for the 3.75-inch rocket which will replace the 3-inch weapon, probably in 1959.

It was agreed that a footnote should be added to Table III indicating that the 3-inch rocket would be superseded, about 1959, by a larger version requiring about 50 per cent. more propellant.

Mr. Litton also pointed out that the plastic propellant which may be required for the 2-inch Air-to-Air Rocket is RD.2317, not RD.2304.

The Chairman said that there were doubts as to whether the 2-inch Air-to-Air Rocket would be required at all and, in any case, the figure of 1,200,000 rounds per annum given by A.D.E. appeared too large. A recent statement by S.D.Arm.P. indicated a probable supply of 500,000 rounds per annum. After some discussion it was agreed that S.D.Arm.P's figure should be given in the Table with a footnote indicating the source and nature of the information. Furthermore, it was decided to use a figure of 20,000 for the 1955/56 estimated requirement, this being considered a reasonable estimate by Mr. Litton.

Dr. Errington then dealt with the figures he had supplied for G.W. requirements and made a number of alterations. He also pointed out that plastic propellant was a potential competitor for use in the Bullpup, Gosling and Mayfly motors, and he suspected that any of the non-G.W. requirements, at present being met with extruded colloidal propellant, could equally well be met with plastic propellant.

Mr. Brewin commented on the hopelessness of trying to formulate propellant requirements for several years ahead in view of the fact that not only the quantity of propellant required, but also the formulation and nature of the propellant, was subkect to change at any time. He suggested that a statement should be included in the report pointing out the desirability for the Services to freeze their demands wherever possible.

Mr. Everett said that this point could best be dealt with by D.M.X.R.D. when he presented the report to the E.D.P.C.

The text of the report was then dealt with.

Modifications were made to emphasise the problematical nature of the 2-inch Air-to-Air Rocket and the possible potential demand for plastic propellant and plastic propellant ingredients.

Mr. Leonard pointed out that the paragraph recommending rehabilitation of the Minsterly ammonium perchlorate factory was not now necessary. This factory has already been rehabilitated and will operate directly the demand for ammonium perchlorate justifies it.

MINISTRY OF SUPPLY

E.D.P.C. 372

Copy No.

EXPLOSIVES DEVELOPMENT POLICY COMMITTEE

PROPELLANTS FOR ROCKETS

Working Party: Second Report

Presented by D.M.X.R.D.

INTRODUCTION

The Working Party's First Report (E.D.P.C. 279, November 1951) dealt with the estimated requirements for Rocket Propellants during the period 1951-1956; the report here presented deals similarly with the period 1956-1960. The estimated requirements, as detailed by the various Services and Development Authorities, are tabulated, and the relation of these to supply possibilities (as far as these can be ascertained) is discussed. Comment is made on the degree of realism in current Propellant Development Policy, and on the advisability of continuing the examination of a number of propellants of which the development in U.K. is at an early stage.

ESTIMATED PROPELLANT REQUIREMENTS

Tables I and II, based on data supplied by D.G.W.R.D., list the Guided Rocket Weapons under development, with details of the motors they use, and state the numbers of motors estimated to be required during each of the years 1955 to 1960, and the differing propellant requirements associated with certain alternatives, as indicated in Appendix I. Table III summarises the demands for motors for both unguided and guided rockets; Table IV summarises the requirements for the various types of propellant; and Table V gives the quantities of basic chemicals needed for the propellants under the alternative assumptions of cordite and plastic propellant for the 2-inch air-to-air (unguided) rocket.

The requirement for the 2-inch air-to-air rocket has been the subject of widely-differing estimates; at one time it appeared that the associated propellant-requirement would dominate the propellant-supply position. Whilst the estimates tabled in this report are believed to be realistic, it is understood that the requirement for the weapon itself is now under review. It is clearly desirable for this uncertainty to be resolved without delay, as the propellant allocation, even on the conservative estimate now presented, is a major one.

Tables III to V include an estimate of propellant requirements for the first year of war. Such an estimate is necessarily most arbitrary, as the direction of increase under war conditions must depend on the stage of development of the various weapons at the date concerned. A supervening emergency in 1955 would, for example, call for a markedly different pattern of production from that to be expected in 1960, when presumably the guided rocket will be a much more highly developed instrument of war.

The following broad conclusions can be drawn from the data presented in Tables I - IV.

Extruded Solventless Cordite and C.D.B.

(i) Until 1960 at least, more propellant will be required for (a) unguided than for (b) guided rockets. Of (a) the largest consumers are (i) the 3-inch air-to-ground, and (ii) the 2-inch air-to-air rockets; (i) is to use extruded cordite, but for (ii) a selection between cordite and plastic propellant has yet to be made. The ultimate choice is important in the present connection because, if cordite, the total demand for extruded

/cordite

cordite in war will approximate to the Bishopton maximal output.

(ii) For guided rockets, envisaged demands for extruded cordite exceed those for C.D.B. in the ratio of about 3 or 4 : 1. The present C.D.B. capacity at Summerfield (500 tons/annum on a one-shift basis) approximates to the postulated 1960 demand (520 tons). It is uncertain whether this requirement will grow, or how far Summerfield's output can be increased with the present equipment. Supplies of "casting liquid" (nitroglycerine ex R.O.Fs., plus triacetin from industry) should be adequate, but, as stressed in the first Report, additional capacity would be required in war for making "casting powder", which is essentially a variant of the "Base-grain" used in making single-base (nitrocellulose) Small Arm propellants.

Some attention has been paid to the possibility of using Ball Powder for C.D.B., but it is not as generally satisfactory as extruded material and its manufacture is difficult when platonising agents must be included.

In considering manufacturing capacity for extruded rocket cordite, account must be taken of the grain-diameters required as well as of tonnages. The nominal output capacity of R.O.F. Bishopton for solventless cordite (15,000 tons/annum) is based on requirements for grains ranging in diameter downwards from 5 inches, the largest required during World War II. Charge-diameters up to 9½ inches are now in demand (e.g. Mayfly, Gosling and Falcon) whilst the extrusion technique is a potential competitor for the larger diameters (up to 16 inches) now being made by casting, i.e. C.D.B. To that end Bishopton's equipment of 15-inch (four) and 10½-inch (sixty) presses is being added to by a 22½-inch press, due at end 1955. With these presses, and presuming the continued successful development of the "long die parallel", D.O.F.(X) reports that Bishopton can meet all requirements for extruded rocket cordite stated in this report, with the possible exception of the uncertain war-time demand for the 2-inch unguided rocket, as indicated above.

Admiralty Interest

In this connection the contribution made by R.N.P.F. to the development of large-diameter extrusion techniques is important. It arises on the one hand from expertise in processing solventless cordite and the availability of large presses, and on the other from the envisaged use of guided rockets at sea. A material addition by R.N.P.F. (at which also a 22½-inch press is to be installed) to the Bishopton capacity for large extrusions would presumably be forthcoming if required.

"Harmonisation"

Becuase of the effect of variations in processing details on rates of burning of cordites, it may be necessary for the propellant for a given motor always to be made at one factory; this undesirable limitation may disappear as manufacturing experience is gained.

Solvent Cordite

The "M7" propellant, an American type of fast-burning solvent cordite containing potassium perchlorate, is used for the anti-tank rockets (H.E.A.T.). The "war requirement has been stated as only 180 tons/annum initially, which would represent an almost negligible proportion of the Bishopton/Garnock capacity, i.e. 35,000 tons/annum of the solvent cordites of classical or picrite types.

Cordite Ancillaries

Ancillary equipments, such as engine-starters and pressurising devices,

/mostly

mostly use extruded cordite. The quantities required are more than minor, amounting to 1,000 tons/annum in peace, 2,000 in war. About one-half consists of I.C.I's Mechanite. The Bishopton and I.C.I. capacities for these variants, respectively, appear adequate. There is a trend towards liquid-fuel engine starters using isopropyl nitrate, with which no supply difficulty should arise.

PLASTIC PROPELLANT

The marked success of "Smoky Joe", the seventeen-inch plastic propellant sustainer motor, in recent trials, both static and flight, has intensified the interest in plastic propellant, with its advantages of, inter alia, high loading density with wide temperature range. Additional large demands for plastic propellant may therefore arise, for both guided and unguided weapons. This, and the possible use of plastic propellant in the 2-inch air-to-air rocket, focus attention on the need for (a) ensuring adequate supplies of the essential ingredients, ammonium perchlorate and polyisobutene, and (b) providing processing equipment on a suitable scale. Thus the 2-inch rocket alone would require, on the estimates herein presented, a processing capacity of 1,000 tons/annum in peace, 5,000 in war (as against the nominal 100 tons/annum, single-shift basis, currently planned), calling for 600 and 3,000 tons, respectively, of ammonium perchlorate. The P.I.B. requirement (about 12 per cent. of the propellant by weight) is relatively small, and stockpiling could be considered, at least as an interim measure.

PRESSED CHARGES

Pressed charges, which are being developed by I.C.I., Ardeer, are so far required for development purposes only, for which not more than 200 tons/annum are estimated up to 1960, the "war" figure being indefinite. Such an output is small compared with the capacity (3,000 tons/annum) of the one large 1,500-ton press so far installed at Ardeer, but at full output additional ancillary equipment would be required. Current pressed charges employ the scarce and expensive guanidine nitrate as fuel for the readily available and cheap ammonium nitrate. If an inexpensive satisfactory carbonaceous fuel can be found or devised, pressed charges are likely to become the cheapest form of solid propellant, especially suitable, perhaps, for A.T.O. motors. Anthracite shows some promise of providing a solution to this fuel problem.

MINOR INGREDIENTS

Critical production difficulties are not anticipated in connection with any of the minor ingredients of these propellants, e.g. nitro-diphenylamine, lead (platonising) compounds, rate-of-burning catalysts, and ester (mainly phthalate) plasticisers. The ultimate identity of the inhibiting coating material for colloidal propellant charges is less clear. Ethyl cellulose is superior to cellulose acetate but is not in production in U.K. Current research is directed to obtaining a type of cellulose acetate less prone to abstract nitroglycerine from the propellant grain, with consequent spoiling of end-of-burning performance, but in the last resort commercial cellulose acetate could be accepted for short "shelf-life".

LIQUID PROPELLANTS

Remarks on liquid propellants are of marginal interest in this report, by reason of the trend towards solid sustainer charges for all rockets currently under development.

Nitric acid (Sea Slug) is in ample supply, as would also be hydrogen peroxide (H.T.P.) for that use alone. Ultimately a solid sustainer for Sea Slug is envisaged.

Assuming the rocket-driven interceptor aircraft to fall within this purview, H.T.P. and liquid oxygen must receive consideration from the supply aspect, that of the petroleum (kerosine) fuel being taken for granted.

/Estimated

PROBABLE REQUIREMENTS FOR GUIDED WEAPON ROCKET BOOST AND SUSTAINER MOTORS

TABLE I

Application	Propellant Type and Charge Weight	Principal features of motor body	Quantities required per annum. (a) No. of motors (b) Propellant weight (short tons)						
			1954-55	1955-56	1956-57	1957-58	1958-59	1959-60	
Blue Sky	Extruded Cordite 32 lb.	Modified version of M.R. A/C5" No. 5	600 10	700 11	600 10	600 10	- -	- -	(a) (b)
Test Vehicles	Extruded Cordite 110 lb.	Light Alloy tube 99" x 7½"	800 44	800 44	500 27	500 27	500 27	500 27	(a) (b)
Test Vehicles Red Duster	Extruded Cordite 260 lb.	Steel tube 111" x 9"	710 92	635 82	740 96	1100 143	2100 273	2500 325	(a) (b)
Sea Slug Blue Slug	Extruded Cordite 330 lb.	Steel tube 118" x 10"	200 33	200 33	400 66	700 116	1600 264	1800 297	(a) (b)
Red Dean	Extruded Cordite 150 lb.	Steel tube 53" x 10" with reinforced plastic pipe	225 17	76 6	90 7	230 17	300 23	800 60	(a) (b)
Red Shoes	Cast Double Base 350 lb.	Steel tube 102" x 12"	200 35	610 106	700 122	1300 227	2500 438	2500 438	(a) (b)
Blue Jay	Extruded Cordite 60 lb.	Steel tube 38.5" x 7.5" with reinforced plastic tail pipe	300 9	200 6	1200 36	2100 63	2000 60	2000 60	(a) (b)
Test Vehicles	P.I.B. Plastic Propellant 43 lb.	Light alloy tube 58" x 5"	1000 21	1000 21	1000 21	500 11	500 11	500 11	(a) (b)
Sea Slug Blue Slug	Cast Double Base 640 lb.	Steel tube 92" x 16" with reinforced plastic tail pipe	100 32	150 48	100 32	125 40	350 112	400 128	(a) (b)
Red Shoes	Pressed Charge 580 lb.	Steel tube 66" x 27" with reinforced plastic tail pipe	150 44	160 47	175 51	325 95	520 151	500 145	(a) (b)
Red Shoes	P.I.B. Plastic Propellant 750 lb.	Steel tube 66" x 17" with reinforced plastic tail pipe	60 23	20 8	- -	- -	- -	- -	(a) (b)
		Extruded Cordite	2835 205	2611 182	3530 242	5230 376	6500 647	9000 769	(a) (b)
	TOTALS:	Cast Double Base	300 67	760 154	800 154	1425 267	2850 550	2900 566	(a) (b)

TABLE I

Motor	Application	Propellant Type and Charge Weight	Principal features of motor body	Quan
				1954
Stork (Boost)	Blue Sky	Extruded Cordite 32 lb.	Modified version of M.R. A/C5" No. 5	60 1
Demon (Boost)	Test Vehicles	Extruded Cordite 110 lb.	Light Alloy tube 99" x 7½"	80 4
Mayfly (Boost)	Test Vehicles Red Duster	Extruded Cordite 260 lb.	Steel tube 111" x 9"	7 9
Gosling (Boost)	Sea Slug Blue Slug	Extruded Cordite 330 lb.	Steel tube 118" x 10"	20
Falcon (Boost)	Red Dean	Extruded Cordite 150 lb.	Steel tube 53" x 10" with reinforced plastic pipe	2
Bullpup (Boost)	Red Shoes	Cast Double Base 350 lb.	Steel tube 102" x 12"	2
Magpie (Boost)	Blue Jay	Extruded Cordite 60 lb.	Steel tube 38.5" x 7.5" with reinforced plastic tail pipe	3
5" LAP (Boost)	Test Vehicles	P.I.B. Plastic Propellant 43 lb.	Light alloy tube 58" x 5"	10
Foxhound (Sustainer)	Sea Slug Blue Slug	Cast Double Base 640 lb.	Steel tube 92" x 16" with reinforced plastic tail pipe	
Elkhound (Sustainer)	Red Shoes	Pressed Charge 580 lb.	Steel tube 66" x 27" with reinforced plastic tail pipe	
Smoky Joe (Sustainer)	Red Shoes	P.I.B. Plastic Propellant 750 lb.	Steel tube 66" x 17" with reinforced plastic tail pipe	
			Extruded Cordite	2
		TOTALS:	Cast Double Base	
			P.I.B. Plastic Propt.	
			Pressed Charge	

TABLE III

ROCKETS (GUIDED AND UNGUIDED)

WEAPON AND MOTOR DETAILS AND ESTIMATED NUMERICAL REQUIREMENTS 1955-1960

Weapon	Motors		Propellant	Weight, per motor, of		Estimated number required in					
	Boost	Sustainer		Propellant (lb.)	Inhibitor (lb.)	1955/56	1956/57	1957/58	1958/59	1959/1960	First year of war
Unguided											
(1) 2-inch Air-to-Air		-	Plastic (P.I.B./Perchlorate) RD 2317 or Cordite F438/649.	3.5	- 0.5	20,000	500,000	900,000	500,000	500,000	2,500,000
(2) 3-inch-Air-to-Ground		-	Cordite SU/K	11.25	0.25	250,000	250,000	250,000	250,000	250,000	600,000
3.5-inch H.E.A.T.			W.7(Solvent Cordite)	0.36	-	300,000	300,000	300,000	300,000	300,000	1,000,000
(3) 4.5-inch H.E.A.T.			ditto	1.23	-			225,000	450,000	900,000	1,400,000
Red Angel			Cordite RE/S	180	-	550	550	550	550	550	550
Guided											
Blue Sky	Stork	-	Cordite F488 type	32	2.3	400	400	600	-	-	-
Sea Slug	Gosling		" " "	310	15.5	200	400	700	1,600	1,800	10,000
" "	"	Foxhound	C.D.B.	644	49	150	100	125	350	400	2,500
Red Duster (and T.V's)	Mayfly	-	Cordite F488 type	260	12.0	635	900	1,300	2,100	2,500	10,000
Red Dean	Falcon	-	" " "	145	9.0	76	90	230	300	800	4,000
Red Shoes	Bullpup		C.D.B.	350	33	610	700	1,300	2,500	2,500	10,000
" "		Elkhound	Pressed (I.C.I.)	580	54	160	175	325	520	500	2,500
" "		Smoky Joe	P.I.B. Plastic	750	-	20	-	-	-	-	?
Blue Jay	Magpie Magpie	-	Cordite F488 type	57	3.1	200	1,200	2,100	2,000	2,000	10,000
T.V's	Demon		Cordite SU/K	110	7.5	800	500	500	500	500	2,500
T.V's	5-inch L.A.P		P.I.B. Plastic			1,000	1,000	500	500	500	?

(1) Based on figures quoted by S.D.Arm.P. for C.M's review, October 1954: Service requirement problematical.

(2) May be superseded about 1959 by a larger version requiring about 50 per cent more propellant and using Cordite of F480 type.

(3) Reserve design - may replace 3.5 inch version.

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TABLE IV

ROCKETS (GUIDED AND UNGUIDED)

ESTIMATED PROPELLANT REQUIREMENTS, 1955-1960

Propellant	Weapon	Maker	Estimated Requirements						Notes
			1955/56	1956/57	1957/58	1958/59	1959/60	1st Year of War	
					(Short Tons)				
Cordite, Extruded, Solventless	Guided								
SU/K	T.V's (Demon)	R.O.F. and R.N.E.F.	40	30	30	30	30		
RS/K	Red Angel; ATO		200	550	750	800	800	1,500	
CSC/K	Ancillaries		60	60	60	30	30	60	
CSC/½K			660	890	840	550	540	1,090	
F547/18			60	60	60	40	40	80	
F488/Type	Blue Sky (Stork)		10	10	10	20	-	-	
	Red Duster (Mayfly) & T.V.s		80	100	150	270	320	1,600	
	Sea Slug (Gosling)		30	70	120	260	300	1,500	
	Red Dean (Falcon)		5	10	20	20	60	300	
	Blue Jay (Harpie)		5	40	60	120	120	600	
	Total for Guided Rockets:		1,150	1,820	2,100	2,140	2,240	6,730	
	Unguided								
SU/K	Various	R.O.F.	130	130	130	130	130	650	
F488/Type	3-inch Air-to-Ground		2,150	2,150	2,150	2,150	2,150	4,300	
" "	*2-inch Air-to-Air		350	850	850	850	850	4,500	Plastic alternative
	Total for Unguided Rockets		2,630	3,130	3,130	3,130	3,130	9,450	
	Total for Guided and Unguided:		3,780	4,950	5,230	5,270	5,370	16,180	
	- ditto- excluding *		3,430	4,100	4,380	4,420	4,520	11,680	
Mechanite	Engine Starters	I.C.I.	670	740	560	385	325	770	
Cordite (extruded, solvent)									
M.7	3.5-inch H.E.A.T.	R.O.F.	54	54	72	72	72	180	
M.7	4.5-inch H.E.A.T.		-	-	140	280	560	840	
	Total:				212	352	632	1,020	
Cast Double-Base									
C.D.B.	Red Shoes (Bullpup)	I.C.I.	100	120	230	440	440	?	
	Sea Slug (Foxhound)		50	30	40	110	130	?	
	Total:		150	150	270	550	570	(1500)+	
Plastic Propellant									
P.I.B. Type	*2-inch-Air-to-Air	R.O.F.	350	850	850	850	850	4,500	Cordite alternative.
" "	Red Shoes (Smoky Joe)		8	?	?	?	?	?	
" "	5" L.A.P. Boost		22	22	11	11	11	?	
Polystyrene "	Torpedo Boost		13	13	13	13	13	?	
Pressed Propellant									
R.C.2. Type	Red Shoes (Elkhound)	I.C.I.	50	50	100	150	150	?	
	Cumrose (Naval) (?ATO)		15	15	?	?	?	?	
G.D. & O.C. Types	Engine Starters, Pressurising, etc.		5	Decreasing				?	
Liquid Propellants					(Long Tons)				
Hydrogen Peroxide (H.T.P.)	Rocket A/C	(Laporte)	3,220	4,420	8,420	10,720	10,820	50,000	
	Underwater Propulsion (Admiralty)		(1,000)	(2,300)	(2,065)	(2,085)	(2,125)	?	
Liquid Oxygen ϕ	Rocket A/C	(B.O.Co.)	5,000	9,800	15,800	23,700	39,500	120,000	ϕ Allowing 50% evaporative loss.
Kerosine	(a) with H.T.P.		500	1,000	1,600	2,400	4,000	12,000	
	(b) with L.O.		1,000	2,000	3,000	4,700	8,000	24,000	
Isopropyl Nitrate	Engine Starters	I.C.I.	100	500	650	650	650	2,000	

ROCKETS (GUIDED AND UNGUIDED)

REQUIREMENTS OF CHEMICALS FOR PROPELLANTS.

CHEMICALS	A. Assuming the 2 in. Air-to-Air Rocket uses F 488/649 (Cordite). REQUIREMENTS (long tons)						B. Assuming the 2 in. Air-to-Air Rocket uses Plastic Propellant REQUIREMENTS (long tons)					
	1955/56	1956/57	1957/58	1958/59	1959/60	1st yr. of war	1955/56	1956/57	1957/58	1958/59	1959/60	1st yr. of war.
I. Basic Chemicals for Solid Propellants.												
Glycerin	650	800	850	1200	1300	2500	600	690	750	1100	1200	1900
Cellulose (Paper)	1120	1470	1560	1590	1610	4850	1010	1220	1320	1330	1360	3500
(Cotton)	17	17	70	110	200	35	17	17	70	110	200	35
(Linters)	250	260	250	290	300	220	250	260	250	290	300	220
Nitric Acid	3430	4300	4550	4800	5100	10300	3180	3690	3950	4200	4500	7100
Sulphuric Acid	1290	1600	1700	1800	1900	3650	1200	1400	1500	1600	1700	2500
Acetone	11.0	11.0	43	70	130	210	11	11	43	70	130	210
Carbamite	165	210	205	180	200	400	160	200	190	160	180	320
Candelilla Wax	5.4	6.6	6.6	7.4	7.6	19	4.7	4.9	5.1	5.7	5.9	10
Carbon Black	0.5	0.5	1.7	2.9	5.1	8.2	0.5	0.5	1.7	2.9	5.1	8.2
Dinitrotoluene	20	55	75	80	80	150	20	55	75	80	80	150
Mineral Jelly	1.2	1.3	1.0	0.7	0.7	1.3	1.2	1.3	1.0	0.7	0.7	1.3
Ammonium Nitrate	20	19	30	45	45	?	20	19	30	45	45	?
Ammonium Picrate	4.0	2.9	1.4	1.4	1.4	?	51	120	115	115	115	600+
Ammonium Dichromate	2.1	2.1	3.1	4.6	4.6	?	2.1	2.1	3.1	4.6	4.6	?
Guanidine Nitrate	38	35	55	80	80	?	38	35	55	80	80	?
Lead Stearate	3.0	2.7	4.5	9.1	9.6	?	3.0	2.7	4.5	9.1	9.6	?
Lead Ethylhexoate	47	58	61	67	69	165	41	43	45	52	53	84
Lead Salicylate	0.4	0.5	0.8	1.4	1.4	?	0.4	0.5	0.8	1.4	1.4	?
Potassium Nitrate	6.0	6.3	6.2	6.4	6.4	4.8	6.0	6.3	6.2	6.4	6.4	4.8
Potassium Perchlorate	2.9	2.9	11.3	19	34	55	2.9	2.9	11.3	19	34	55
Titanium Dioxide	0.3	0.2	0.1	0.1	0.1	?	3.4	7.8	7.7	7.7	7.7	40
2. Nitrodiphenylamine	1.7	2.1	4.1	7.8	7.8	?	1.7	2.1	4.1	7.8	7.8	?
Potassiumcryolite	13	21	25	24	24	76	13	21	25	24	24	76
Ammonium Perchlorate	29	24	17	17	17	?	250	560	550	550	550	2800+
Lecithin	0.4	0.3	0.2	0.2	0.2	?	3.5	7.9	7.8	7.8	7.8	40
Dibutyl Phthalate	250	300	300	300	300	700	225	250	240	236	245	410
Dimethyl Phthalate	1.7	2.0	3.9	7.4	7.4	?	1.7	2.0	3.9	7.4	7.4	?
Triacetin	17	16	21	30	32	13	17	16	21	30	32	13
Cellulose Acetate	6.4	6.4	6.4	4.3	4.3	8.6	6.4	6.4	6.4	4.3	4.3	8.6
Polyisobutene	3.4	2.6	1.3	1.3	1.3	?	43	100	96	96	96	500+
Polystyrene	1.2	1.2	1.2	1.2	1.2	?	1.2	1.2	1.2	1.2	1.2	?
Sucrose Octa Acetate	4.3	2.5	3.4	9.3	11.2	?	4.3	2.5	3.4	9.3	11.2	?
II. Basic Chemicals for Inhibitors.												
Cellulose Acetate	59	63	60	67	68	220	59	63	60	67	68	220
Carbamite	4.4	4.7	3.9	3.1	3.1	6.8	4.4	4.7	3.9	3.1	3.1	6.8
Triacetin	35	37	31	25	25	54	35	37	31	25	25	54
Ethyl Cellulose	12	114	120	130	135	660	7.8	10.6	17	26	31	150
Mixed Esters	4.7	15	18	26	26	170	4.3	4.7	8	16	16	120
III. Basic Chemicals for Igniters.												
Potassium Nitrate } SR 371 C	2.2	4.1	4.1	4.3	4.3	16.0	2.2	4.1	4.1	4.3	4.3	16.0
Magnesium } SR 371 C	1.8	3.5	3.5	3.6	3.6	13.4	1.8	3.5	3.5	3.6	3.6	13.4
Acaroid Resin } SR 371 C	0.4	0.7	0.7	0.7	0.7	2.6	0.4	0.7	0.7	0.7	0.7	2.6
Potassium Nitrate } Gunpowder	10.0	11.0	10.0	7.7	7.7	20.0	10.0	11.0	10.0	7.7	7.7	20.0
Charcoal } Gunpowder	1.9	2.1	1.9	1.5	1.5	3.8	1.9	2.1	1.9	1.5	1.5	3.8
Sulphur } Gunpowder	1.3	1.5	1.3	1.0	1.0	2.6	1.3	1.5	1.3	1.0	1.0	2.6
IV. Basic Chemicals for Liquid Propellants.												
Kerosine (for Liquid Oxygen) x	1000	2000	3000	4700	8000							

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Return by (06/03/2013 10:58:15)

8278188 (Peter Blake)

Closure status: Open

S 23/01/2013 10:58:15