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TECHNICAL REPORT No. 485-45

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GERMAN POWDER COMPOSITION AND INTERNAL BALLISTICS FOR GUNS

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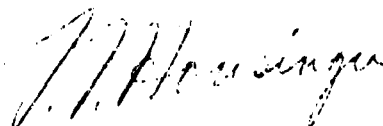
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TECHNICAL REPORT No. 485-45

GERMAN POWDER COMPOSITION AND INTERNAL BALLISTICS FOR GUNS

SUMMARY

This report gives a list of propellant powder compositions for German guns from 20 mm upwards together with the internal ballistics produced in each gun. A short statement on methods of internal ballistic calculation and also on closed bomb determination of ballistic constants is included.

October 1945

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TABLE OF CONTENTS

	<u>Page</u>
Part I. Introduction	3
Part II. Measurements and Calculations	3
(A) Calorie Value Calculations	3
(B) Closed Bomb Work	3
(C) Method of Analysis of Records	5
(D) Application to Gun Calculations	6
(E) Special Closed Bomb Investigations.	7
Part III. Tables	
(A) Index of Abbreviations	8
(B) German Powder Compositions.	9
(C) German Gun Internal Ballistics	11

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Closed Bomb Work and Internal Ballistics Calculations (B)(Cont'd).

work was done in the Deutsche Waffen Munition-Fabrik research laboratory at Lütbeck.

2. Apparatus Closed bombs of various capacities up to three and one-half liters were used. They were constructed with a liner and shrunk-on jacket and were tested at 30 tons/sq.in. The chamber length was usually five or more diameters. The cooling water was pumped through a water jacket from a thermostat.

The charges were loaded in much the same way as in the gun and with a similar ignition system, i.e.: gun powder with or without NC igniters. The breech end was closed by a steel cartridge case containing a percussion primer. This case was reformed after each round and had a life of about 30 rounds. (It is said that some used a mushroom head with rubber gasket).

Zeiss-Ikon piezo-electric recording sets were available at Lütbeck, Düneberg and Essen. That a Lütbeck was used for closed bombs, rockets and guns. Calibration was by the simple press supplied by Zeiss-Ikon and of the approximate accuracy of 2%. The set at Düneberg was similar but seldom used as a mechanical gauge was preferred. At Essen both piezo-electric and mechanical gauges were used and both considered accurate, but a special unit was made to calibrate either type of gauge in position in the closed bomb. Krupps also used a piezo-electric gauge for gun measurements both in the chamber and on the base of the projectile.

The mechanical gauge used at Düneberg was quite accurate utilizing a one piece beam of flexible steel with a mirror mounted on each end and the piston from the bomb working against the center of the beam. A beam of light passed over first one mirror and then the other and thence to the sensitive paper thus giving double optical deflection. The gauge was calibrated in position by a dead weight testing machine. Waterproof recording paper was used to minimize shrinkage in processing and this error was allowed for by printing two accurate centimeter scales over the record.

All the gauges used the same piston for transmitting thrust from the gases. This protruded into a recess inside the vessel and was protected by a thimble filled with grease which formed the obturation. Its cross sectional area was 0.250 sq.cms.

100

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Closed Bomb Work and Internal Ballistics Calculations (B)(Cont'd).

In the piezo-electric sets the time-scale was provided by a flashing tube controlled by a 1000 cps tuning fork. For the mechanical gauge the time scale was provided by accurate control of the angular velocity of the drum.

By means of the thermostat the closed bomb could be fired either at normal or high temperatures but no provision was made for low temperatures.

(C) Method of Analysis of Records. Powders were almost invariably fired in the form of tube, strip or flake, all assumed to have constant burning surface.

For any given size of a given powder composition, measurements of force and covolume were made by firing one round at each of five or more densities of loading. Then if P_{Max}/Δ were plotted as a function of $P_{\text{max}} > 1500$ atm. would lie on a straight line. The intercept of this line on the zero pressure line gave the force constant, F , and the slope gave the co-volume N . Since no heat loss correction was applied, the values of F and N depended on the web size of the powder, F diminishing N increasing with increase in web size.

Two methods of determining the relative quickness of the powder were used, depending on the use to which the results were to be put.

The simple method assumed a linear rate of burning law and no co-volume correction. Under such circumstances the pressure must be an exponential function of the time. Times were measured at which the pressure reaches P , and P_{ie} , where P , is some arbitrary pressure, about $1/3$ of P_{max} and $e = 2.718$. If T is the time interval from P , to P_{ie} , then $TP_{\text{max}} - Y$ equals D/B the reciprocal of the relative quickness. The beginning and end of the pressure curve are not used because they depart from the ideal exponential curve, mainly owing to irregularities in ignition. The relative quickness obtained by this method is almost independent of the density of loading for deglycol powders. For gudol powders, however, the relative quickness diminishes at higher densities of loading and the figure used is that for which P_{max} equals the maximum pressure to be expected in the gun.

At Essen a more elaborate analysis was used, the appropriate force and co-volume constants being used to calculate Z , the fraction of the charge burnt, at each of some 20 constants of time for which the pressure was read off the curve. Then $S Pdt$ was plotted as a function of Z

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Closed Bomb Work and Internal Ballistics Calculations (B) (Cont'd).

and the slope of the middle part of this curve, which was nearly linear, gave Y. Results varied slightly for different densities of loading and a mean value was taken.

For experimental powders log P was plotted against time, using logarithmic graph paper, and the curvature of the line showed whether the powder were progressive or degressive.

(D) Application to Gun Calculations. For most purposes a very simple method of gun calculation was used, similar to the old ADD method. The closed bomb figures for F and N are estimated for about the right web size. The powder was assumed to be all burnt before the shot started to move, giving a pressure

$$P_o = F/l/\Delta - N$$

The gas was then assumed to expand adiabatically, using a value of 2 given by:

$$F = 1 + F/(J \times \text{cal. cal.})$$

1.2

where HJ is the mechanical equivalent of heat in the appropriate units. This adiabatic curve was then intersected by a constant pressure line $P = P_{\text{max}}$ (crusher) and this line together with the adiabatic line to the muzzle gave the pressure-space curve used for design purposes. A factor of 0.96 was then used to allow for rounding off the corners of the diagram in calculating the muzzle energy $(W + C/3) W^2$. A further 3% or 5% was subtracted from the muzzle energy to allow for the frictional losses with one or three driving bands respectively. This method did not involve propellant size or the position of all burnt, but gave reasonably accurate results in experienced hands.

A more elaborate method was used by Krupps in detailed design of new weapons. This used closed bomb data for force, co-volume and relative quickness and started from a shot start pressure. The co-volume correction was applied in a step by step integration.

In choosing a given solution for use it was considered that the velocity at burnt should never exceed 90% of the muzzle velocity in order to obtain reasonable regularity. This gave a minimum value for the relative

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Application to Gun Calculations (D)(Cont'd).

quickness of the powder. For low performance weapons, of course, V burnt would be about 20% less than V_o .

(E) Special Closed Bomb Investigations. Three special closed bomb investigations deserve mentioning. In the first place a study of the effect of moderation on the burning properties of small arms powders was made both in the closed bomb and in the gun, at Ldbeck. For chopped NC tube moderated with about 4% methyl centralite or camphor the progressiveness due to the moderation counterbalanced the degressiveness due to the shortness of the tubes, giving an effectively constant burning surface.

Secondly at Däneberg a long and detailed study was made of the effect of varying the ratio of external to hole diameter, and of tube length to hole diameter, on the burning properties of powder at various temperatures. The general conclusions reached were as follows:

(a) The mean rate of burning increased and became more irregular when the stick length exceeded thirty times the hole diameter. The temperature coefficient also increased in the same way.

(b) The mean rate of burning became irregular if the ratio of external to hole diameter exceeded 2.5 for powders with cal. vol 800 or 2.0 for powders with lower cal. vols. Since different factories produced powders with different ballistic properties it was necessary to lay down tolerances for hole size as well as annulus and tube length in order to obtain both the required relative quickness and temperature coefficient. This work was carried out in conjunction with gun firings.

A third investigation was the effect of atmospheric humidity on moisture content and so on ballistics, but this was done mainly by gun firings.

Other investigations included the taking of gas samples from guns or closed bombs by means of a small evacuated closed vessel placed in the chamber or screwed into the wall. This small vessel was sealed by a disc, which ruptured at a suitable high pressure and admitted the gas sample. Experiments with this apparatus showed that for Ngl, and Digl. powders the gases had approximately the calculated composition but that for gudol powders the water gas equilibrium constant was well below the theoretical value. This was believed to be due to the shortage of oxygen in such powders. The continued pressure rise in closed bombs firing Gudol powders after the

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Special Closed Bomb Investigations (E)(Cont'd).

charge should be all burnt was believed to be due to completion of some gas reaction which could only proceed slowly with such powders.

A somewhat similar apparatus, in which the gases produced in a small closed bomb ruptured a disk and expanded into a larger closed bomb was used for measuring the smoke produced by various powders. In this case the large vessel was fitted with a light source and photocell.

Notes and Abbreviations to Tables.

1. Theoretical cal. vol. in Table I have been calculated by personnel of Armament Research Department, Woolwich, England.

2. Units of Force in Table I and II are tons/sq. in. per gram centimeter.

3. Additional German values not given in the British translation of these tables are included in Appendix to Tables.

4. Abbreviations:

NC	Nitrocellulose
% N	Nitrogen content of NC by weight.
NG	Nitroglycerine
DGN	Diethylene glycoldinitrate
Trigl	Triethyleneglycoldinitrate
Pic	Nitroguanadine
Akar	Akardite
Centra	Centralite I
MgO	Magnesium Oxide
Graph	Graphite
N ₁	Nitronaphthalene
Hydr.	Hydrocellulose
DNT	Dinitrotoluene
MJ	Mineral Jelly
Phth	Diamylphthalate
Ephu	Ethylphenylurethane
Dphu	Diphenylurethane

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APPENDIX TO TABLES

Supplementary Data on German Powder Compositions

Powder No.	Description	German Theor.		Specific Gas. Vol. CM ³ /kg.
		Cal.Val.	Cal/gm	
1	Ngl. Pl. P-12.5	1198		814
2	Ngl. Bl P-12.5	1144		829
3	Ngl Blp - 11.5	1023		869
4	Ngl. RP - 9.5	832		943
5	Ngl RP - 8	725		981
6	RP 32	719		938
7	Digl. BIP - 10.5	925		953
8	Digl. BIP - 10.5	916		957
9	Digl. RP - 9.5	841		970
10	Digl. RP - -0.3	740		994
11	Digl. RP - 8.2	717		1005
12	RP - 38	686		1019
13	RP - 38N	695		1010
14	RP - E	579		1066
15	Digl. RP - KO	571		1088
16	Digl. RP - KN	559		1055
17	Digl. RP - KOD	575		1052
18	Digl. RP - GO	503		1123
19	Digl. RP - GO.5	497		1108
20	RP 40	540		1078
21	RP 40N	577		1063
22	Digl. RP-G1.5	498		1920
23	Digl. RP - G 2.5	509		1069
24	Digl. RP - G.5	---		1035
25	LgP 40N	---		---
25a	Lgp 40	---		---
26	Gup - AO to al.3	830		993
27	GuRP - 39	713		1023
28	GuRP - 7.5	537		1100
29	GuRP - 8	736		1007

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Appendix to Tables (Cont'd).

Powder No.	Description	German Theor.		Specific Gas. Vol.
		Cal.Val.	Cal/gm	CM ³ /kg
30	GuRP - KN		518	1074
31	GuRP - GO		531	1102
32	GuRP - G5		476	1051

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GERMAN GUN PROPELLANTS

Powder No.	Type	User	Composition in % by weight								Cal. Val. cal/gm	Force British Units	T ₀ °K	Theor. Cal.Val. cal/gm				
			1. Nitroglycerine Powders															
			N.C.	StN	M.G.	Akar	Centr	MgO	Graph									
1.	Ngl.P1.P-12,5 -	Army	54.40	12.90	44.20	0.30	1.00	0.05	0.05		1290	79.4	4065	1297				
2.	Ngl.B1.P-12,5 -	Army	59.31	12.75	39.54	0.25	0.75	0.05	0.10		1255	77.8	3910	1256				
3.	Ngl.B1.P-11,5 -	Army	57.75	12.75	38.90	-	3.60	0.05	0.10		1150	74.1	3550	1159				
4.	(Ngl.R.P. - 9,5 - R.P. 12 or RPC/12)	Army Navy)	64.13	11.90	29.77	-	5.75	0.25	0.10		950	67.3	2975	938				
5.	Ngl.R.P. - 8 -	Army	67.07	11.40	26.08	-	6.50	0.25	0.10		840	62.5	2650	827				
6.	R.P. 32 or RPC/32	Navy	66.60	11.50	25.90	-	7.25	0.15	0.10		830	62.4	2650	816				
			2. D. E. G. D. N. Powders															
			N.C.	StN	D.G.N.	Akar	Centr	MgO	Graph	α Kn	M.J.	Phth.	K ₂ SO ₄	KNO ₃				
7.	Digl.B1.P.-10,5 - (Howitzers)	Army	33.62	13.00	35.78	0.25	0.25	0.05	0.05						1020	72.1	3150	1005
8.	Digl.B1.P.-10,5 - (Primary charge)	Army	54.72	13.00	44.78	0.25	0.25	-	-						1020	72.0	3130	1012
9.	Digl.R.P. - 9,5 -	Army	61.80	12.60	36.45	-	1.50	0.15	0.10						950	68.4	2940	933
10.	Digl.R.P. - 8-0,3 (3.7-ca. Flak)	Flak	68.30	11.90	29.25	-	2.20	0.15	0.10					0.30	870	63.2	2650	840
11.	(Digl.R.P. - 8,2 - Digl.R.P. - 8 -)	Flak Army	67.70	11.90	29.05	-	3.00	0.15	0.10						820	62.2	2570	809
12.	R.P. 38 or RPC/38	Navy	69.45	12.20	25.30	-	5.00	0.15	0.10						810	61.0	2495	765
13.	R.P. 38 N	Navy	68.72	12.20	25.03	-	1.50	0.15	0.10	4.50					810	61.7	2545	774
14.	R.P. - 8 -	ALL	60.55	12.00	25.95	-	3.75	0.15	0.10	2.50	(4.00	D.N.T.	3.00 Hydr.)		730	55.2	2175	638
15.	Digl.R.P. - K.O. - or - K.I. -	Flak	64.15	12.00	27.50	-	5.35	0.15	0.10		1.85	0.90	0 or 1.00		725	55.5	2125	634 or 633
16.	Digl.R.P. - K.N. -	Flak	61.08	12.00	26.17	-	7.00	0.15	0.10		1.25	0.25		4.00	730	53.8	2125	665

[illegible]

GERMAN INFANTRY BALLISTIC DATA

Sheet 1

No.	Gun	Calibre mm.	Type	Powder	Charge wt. lbs.	Shot wt. lbs.	Chamber length mm.	Shot travel mm.	Total cap. lbs.	Pressure		M.V. m/s	Projectile
										Barrels	Design		
-	2 cm Flak 30	30	Na. R.P.	3 x 3/0.5 2.5 x 2.5/0.5	.098 .040	.134 .115	110.5	1170.5	.434	3900	3900	855 900	R.E. tracer R.E. tracer
-	3 cm Flak M.44	30.8	"	3 x 2.8/0.6	.170 .150	.330 .285	300 477	2000 2000	1.480	2800	3300	1070 900	R.C.H.E. 44 A.P.H.E. 44
12.	3.7 cm S.L. C/30	37	R.P. 30	3.95 x 2.4/0.6	.345	.745	357	2473	3.87	2850	3450	1000	R.E. tracer 41
12.	3.7 cm Flak M.42	37	R.P. 308	180 x 1.0/0.8 175 x 1.0/0.85	.180 .195	.635 .565		-	-	2800	3150	885 885	R.E. 18 R.C.H.E. 18
12.	3.7 cm S.L. C/36	37	R.P. 308	180 x 1.8/0.8 175 x 1.8/0.85	.180 .195	.635 .565	216	1895	2.09	2800	3800	840	R.E. 18 R.C.H.E. 18
16.	3.7 cm Flak 28	37	Magl. R.P. - 8-	201 x 2.2/0.85 186 x 2.2/0.85	.180 .182	.685 .685	215	1876.8	2.35	2575	2900	840	R.E. 18 A.P. 18
16.	3.7 cm Flak M(1/05)	37	Magl. R.P. - 8.2-	310 x 3/1	.320	.685	340	1970	2.75	2800	3030	885	A.P.
26.	1. Pz 41	42/37	Q.L.R. - 40.5-	315 x 2.3/1	.480	.360		-	-	-	-	-	A.P.
12.	(Mod. 1) 2472		Magl. R.P. - 6.1-	310 x 1.8/1	.304	.330		-	-	-	-	-	-
16.			Magl. R.P. - 6.1-	310 x 2.6 x 0.5	.307			-	-	-	-	-	-
50	50	55	Not in Service			1.8	510.5	5538	-	3000	3800	1980	
50	50	55	Not in Service			1.8	480.7	3795.5	-	3000	3800	1070	
19.	5 cm Flak 36 (1/50)	50	Magl. R.P. - 60.5-	300 x 2.4/1	.755	2.1 1.86	335	1973.5	5.3	2800	3300	780	A.P. R.E.
18	5 cm Flak 36 (1/60)	50	Magl. R.P. - 60.5-	310 x 3/1	.900	2.08	377	2473.5	6.3	2800	3300	835	A.P.
26.			Q.L.R. - 40 -	4.3 x 4 x 0.6	.836	1.86		"	"			550	R.E.
26.			Magl. R.P. - 10.5-	345 x 1.4/0.8 (1.686)				"	"			1180	A.P. 40
10.			Magl. R.P. - 6.2-	288 x 2.4/0.85	.707	0.80		"	"				

Sheet 2

Order No.	Gun	Calibre mm.	Powder		Charge wt. kgs.
			Type	Size mm.	
11. 7. 7.	5 cm. PaK. (K.R.T.) (Cassette & tower)	50	Dgl.R.P.-8.2- Dgl.R.P.-10.5- Dgl.R.P.-10.5-	310 x 4.4/2 3 x 3 x 0.8 285 x 75 (1 tube)	.770 .216
	5 cm. PaK. (K.R.T.) (Cassette & tower)	50	As first two charges of PaK 38 (1/60)		
12.	5 cm. PaK automatic	50	Dgl.R.P.-G 1-	235 x 2.5/1	.655
15.	Gerat 58	50	Dgl.R.P.-MD.5-	370 x 3.6/1.5	1.02
18.	7.5 cm. Inf.K.40 & 7.5 cm. Stu.K.40 (tank and S.P.)	75	Dgl.R.P.-GO.5-	420 x 3.2/1.5 370	-
36. 12. 12.	7.5 cm. Inf.K.42	75	or Dgl.R.P.-G 1- Dgl.R.P.-G 1- Dgl.R.P.-GO.6-	560 x 4.1/1.5 560 x 5/2 530 x 6/4	4.12 4.12 2.3
- 4. 12.	7.5 cm. S.K. G/34 (1/33)	75	or Nz. R.P. or Ngl. R.P. or R.P. 38N	300 x 6.5/1.6 290 x 4.2/2.6 290 x 3.9/2.6	0.93 1.00 0.90
1.	1. I G 18 (1/11.8) (For infantry)	75	1. Ngl. PLP-12.5- 2. Ngl. PLP-12.5- 3. " 4. " 5. "	50 x 0.2 73.5 x 0.8 " " "	.0155 .0220 .0310 .0475 .0715
			7t. of Ch. 1 is included in Ch.		
			1. "	50 x 0.2	as
			2. "	73.5 x 0.8	above
			3. "	"	
			4. "	"	
			5. "	"	

Shot wt. kgs.	Chamber		Shot travel mm.	Total cap. litres	Pressure		M.V. m/s	Projectile
	Length mm.	Cap. litres			Working	Design		
2.06 1.82	335	1.1	2973	7.3	2300	3300	870 575	ncze/ A.P. fuze H.E.
2.06 1.82	369.5	1.23	2973.5	7.19	2600	3500	870 575	A.P. H.E.
2.06 2.195	292.5	.823	3038	7.48	2800	3500	850 860	A.P. H.E.
2.0	388	1.41	3880	9.05	3000	3700	1020	A.P. 5-3 cal.
6.8 4.10 5.74 6.2 4.57 4.4 5.0	577.6	3.17	-	-	-	3600	780 990 565 555 485 405 465	A.P. 38 A.P. 40 H.E. 34 H.E. (heavy) 38 H.E. 38 H.E. 38 H.E. 38
6.8 "	609.2	5.1	4416	25.1	3000	3600	955 "	A.P. 38/40 "
5.74	578.2	4.9	4447		1300	"	700	H.E. 42
5.85	325.5	1.45	2179.5	11.34	2400	2900	620	H.E.
5.45	60.6	0.24	721.2	3.58	1400	1800	95 112 134 172.5 231	H.E. 18 " " " "
2 to 5 to give total wt. of the composite charge. 6.00							82 109.5 151.5 157 311.5	H.E. 18 " " " "

Order No.	Gun	Calibre mm.	Powder		Charge wt. kgs.	Shot wt. kgs.	Chamber		Shot travel mm.	Total cap. litres	Pressure		M.V. m/s	Projectile
			Type	Size mm.			Length mm.	Cap. litres			Working	Design		
1.	7.5 cm. Br. X & Stu. G. (Tank & S.P.)	75	Hgl. H.P.-12.5- (also Hgl. R.P.)	50 x 0.2	.040 .370	5.74 6.80 4.40 6.80 6.80	183.7	0.9	1363.5	7.2	2400	2800	420 385 450 420 430	H.E. 34 H.E. H.E. 34 ant. non-bond soft.
7.	Feb. Gesch. 36 (Mountain Gun)	75	1. Dgl. R.P.-10.5	2 x 2/1	.125	5.74	186	0.9	1054	5.75	2600	3100	200 240 285 354 475	H.E. 34
2.			2. "	"	.158	"	"	"	"	"	"	"	240	"
3.			3. "	"	.203	"	"	"	"	"	"	"	285	"
4.			4. "	"	.273	"	"	"	"	"	"	"	354	"
5.			5. Dgl. R.P.-9.5-	150 x 2.5/1	.530	"	"	"	"	"	"	"	475	"
6.			Ch. is all one size, not composite.											
7.			1. All charges as above.		5.83								200	H.E.
8.			2. "		"								238	(Aluminium)
9.			3. "		"								280	(Dum)
10.			4. "		"								358	
11.			5. "		"								475	
12.	2. Geb. K.15 (Mountain gun)	75	1. (Hgl. H.P.-	10x10x1.5	.147	5.74	180.4	0.9	829.6	4.5	2100		355	
13.			2. (12.5-	"	.182	"	"	"	"	"	"		283	H.E. 15 (red)
14.			3. ((inc. 60 gms. 4x4x1)	"	.232	4.56	"	"	"	"	"		304	
15.			4. Hgl. R.P.-9.5-	12.5x3/1.8	.330	"	"	"	"	"	"		328	H.E. 15
16.			(inc. 10 gms. Hgl. R.P.-12.5- 50 x 0.2)											
17.			Ch. 4 does not contain any Hgl. H.P. from the other charges.											
18.	2. P.F. 18 (Light field gun)	75	1. Dgl. H.P.-10.5	50 x 0.15	.074	5.83	248.3	1.25	1483.7	8.05	2500	2800	185	H.E. 34
19.			2. Dgl. R.P.-60.5-	170 x 2/1	.344	"	"	"	"	"	"	"	370	
20.			3. "	"	.509	"	"	"	"	"	"	"	500	
21.			Wt. of ch. 2 and 3 is total wt. of composite charge											
22.	1. G. Gr. 7. 34 (Heavy mortar)	80	1. Hgl. R.P.-12.5-	1 x 1 x 0.2	.010	3.5	-	-	-	-	400	850	75	H.E. 34
23.			2. Hgl. R.P.-12.5-	0.4 x 60/30	.019	"	"	"	"	"	"	"	105	(Mortar)
24.			3. "	"	.057	"	"	"	"	"	"	"	150	ball.
25.			4. "	"	.024	"	"	"	"	"	"	"	154	
26.			Ch. 1 is the primary and 15c wt. is included in other charges.											

Sheet 2

Powder No.	Gun	Calibre mm.	Powder		Charge wt. kgs.	Shot wt. kgs.
			Type	Size		
4	8.8 cm. S.R. Q/25. Q/31 or L/7.5	88	R.P.Q/12	800 x 8.75/4	4.53	9.0
6			or R.P.Q/32	800 x 5.5/2	4.68	"
12			or R.P.Q/38	800 x 5.5/1.9	4.50	"
			R.P.Q/32	800 x 7/5.25	2.70	"
			or R.P.Q/38	800 x 7/4.9	2.70	"
22			or R.P.40	785 x 4.3/3.0	2.80	"
+			R.P. for Lg. 6.75	785 x 5/4	2.10	9.4
25a			or Lg. P.40	785 x 4.5/3.5	2.05	"
4	8.8 cm. Ttte. K. I/45 (torpedoboot gun)	88	(Ngl. R.P.	290 x 4.5/2)	1.420	9.75
6			(" "	290 x 4.5/2.5)		
12			or R.P.Q/38	290 x 4.0/1.8	1.48	"
25a			Lg. P.40	255 x 4.2/3.2	0.85	8.0
6	8.8 cm. S.R.C/30	88	R.P.Q/32	495 x 5/2.75	2.38	9.0
50			or Q/32, or Q/38	495 x 5.5/2.75	2.53	"
22			or R.P.40	480 x 4.3/1.7	2.90	"
25a			Lg.P.40.	480 x 4/2.4	2.15	9.4
6	8.8 cm. S.R.C/32	88	R.P.Q/32	495 x 4.75/1.5	3.02	9.0
12			or R.P.C/38	495 x 4.5/1.5	"	"
25a			Lg.P.40	480 x 3.2/2.8	1.70	9.4
6	8.8 cm. S.R.C/35	88	R.P.C/32	320 x 4.2/3	1.75	9.0
12			or R.P.C/38.	320 x 4.2/2	1.78	"
21			or R.P.40M	300 x 3.6/1	2.10	"
25			Lg.P.40M.	305 x 2.5/1	1.60	9.4
11	8.8 cm. Flak 18 and 36	88	Dgl.R.P.- K1-	500 x 4.5/1.8	2.85	9.0
15			Dgl.2.P.-R.2-	495 x 5.5/2.75	2.55	"
16			do.	460 x 5.5/2.75	2.55	9.5
30	8.8 cm. Flak 41	88	Gu.R.P.-K N-	740 x 4.2/1.5	5.5	9.4
28			Gu.R.P.- 7.5-	740 x 4.7/1.5	5.5	10.2

Chamber		Shot travel mm.	Total cap. litres	Pressure		M. V. m/s	Projectile
Length mm.	Cap. litres			Working	Design		
				kg/sq.cm.			
838.5	6.35	5501.5	41.43	3100	3900	1080	H.P. 1/4.4 " nose fuse " ditto 825 " H.P. or " practice. 650 Star 1/4.5
321	2.33	3410	23.82	2600	2600	650	H.P. 1/3.8 " or 1/3.8, both " nose fuse. 450 Star 1/3.5
530.7	3.87	3375.3	23.52	2750	3100	795	H.P. 1/4.5 " nose fuse. " ditto 650 Star 1/4.4
530.7	3.87	5808.8	36.50	3150	3600	950	" as above 650 "
348.7	2.49	-	23.40	2500	3000	700	" as above " ditto 800 "
530	3.67	4159.3	29.61	2800	3350	840	H.P. 1/4.5 " nose fuse. 850 A.P.
780	6.80	5510	40.3	3000	3600	1080	H.P. 1/4.9 880 A.P. 39

Sixat 5

Powder No.	Gun	Calibre mm.	Powder		Charge wt. kgs.	Shot Wt. kgs.	Chamber		Shot travel mms.	Total cap. litres	Pressure		M.V. m/s.	Projectile
			Type	Size			Length mms.	Cap. litres			Working kg/sq.cm.	Design		
31.	8.8 cm. Kr.X.43 and PaK 43	88	Gu.R.P.-G 0 -	700 x 8/8 650	3.4	9.4	746	8.8	6010	41.82	-	-	750	H.E. 43
19.			or Dgl.R.P.-G 1 -	700 x 6/4.5 650	"	"	"	"	"	"	"	"	"	"
31.			Gu.R.P.-G 0 -	725 x 5.1/2 650	6.8	10.16	781	9.0		2900	3600	1000	A.P. 39/43	
1A.			or Dgl.R.P.-G 0 -	725 x 6.1/2.5 650	7.0	"	"	"		"	"	"	"	"
The double numbers under size mean two lengths of tube.														
12. 25a.	10.5 cm. S.K. C/28	105	R.P. 38	780 x 6.8/3.2	5.65	14.7	813.9	8.36	4616.6	49.46	2700	3900	925	H.E. 1/4.1
			Lg.P.40	780 x 4.5/3.5	2.80	14.6				2200			650	Star 1/4.2
6. 21. 25a.	10.5 cm. S.K. C/32	105	R.P. 38	550 x 6/3.5	4.05	15.1	586.5	5.38	3813.5	38.23	2850	3200	785	H.E. 1/4.4
			or R.P. 38	550 x 6/3	4.10	"						"	"	"
			or R.P.40M	540 x 4.4/1.7	4.50	"						"	"	"
			Lg.P.40	544 x 4.2/2.6	3.15	14.7						650	Star 1/4.1	
6. 21. 25a. 25.	10.5 cm. S.L. C/33	105	R.P.38	665 x 6.25/3	5.02	15.1	698	7.31	5650	56.15	2850	3600	907	As above
			or R.P.40M	665 x 5.6/2.2	5.80	"						"		
			Lg.P.40	665 x 4.2/3.2	2.85	14.7						650		
			or Lg.P.40M	665 x 3.7/2.5	"	"						"		
11. 16. 11.	10.5 cm. Flak 38	105	Dgl.R.P.-8.2-	665 x 6.25/3	5.00	15.1	688	7.31	5650	56.15	2850	3400	900	H.E. 1/4.4
			or Dgl.R.P.-X 2-	665 x 5.2/1.5	6.00	"						"	"	"
			Dgl.R.P.- 8 -	665 x 6.25/3	5.00	15.56						860	A.P.	

Powder No.	Gun	Calibre mm.	Powder		Charge wt. kgs.	Shot wt. kgs.	Chamber		Shot travel mm.	Total cap. litres	Pressure		M.V. m/s	Projectile
			Type	Size			Length mm.	Cap. litres			Working	Design		
7.	1. P.H. 18 (light howitzer) or 1. P.H. 18 M (with muzzle brake)	105	1. Digl.B1.P.-10.5	3 x 3 x 0.8	.245	14.81	211.7	2.2	2493.3	24.4	2500	2850	208	M.F.
			2.	"	.308	"	"	"	"	"	"	"	240	"
			3.	"	.378	"	"	"	"	"	"	"	272	"
			4.	"	.498	"	"	"	"	"	"	"	326	"
			5.	"	.685	"	"	"	"	"	"	"	401	"
			6.	"	.222)	"	Total ch.wt. 1.022 kg.		"	"	"	"	460	"
			(plus "	4 x 4 x 1.2	.800)	"			"	"	"	"		"
8.			Alternative charges giving the same velocities are as follows.											
24			1. Digl.B1.P.-10.5	10x10x0.2	.190									
			2. Gu. B1.P.-A 0 -	4 x 4 x 0.6	.262									
			3.	"	.342									
			4.	"	.479									
			5.	"	.695									
			6.	"	.280)		Total ch.wt. 1.080 kg.							
			(plus "	8 x 8 x 0.9	.820)									
8			1. Digl.B1.P.-10.5	10x10x0.2	.190									
			2. Nz.B1.P.	6 x 6 x 1	.254									
			3.	"	.328									
			4.	"	.470									
			5.	"	.692									
			6. Nz.B.P.	175 x 5.5/2	1.060									
			Nts. of ch. 2 to 5 include ch. 1 in the composite charges. Ch. 6 does not include ch. 1.											
12.	10 cm. R (M.T.) (casemate & tower)	105	Digl. R.P.-G 0.5-	345 x 3/1.2	2.65	14.95	385	3.64	2565	26.85	2500	3100	630	M.F. 34
			Nz.R.P.	345 x 5.9/1.3	2.20	14.00							640	"
19.	10 cm. R.12 (heavy gun)	105	Digl.R.P.-G 0.5-	450 x 3.1/1.5	2.40	15.14	791.5	7.80	4300.5	47.40	2700	3150	550	M.F. 19
22.			"	"	3.40	"							690	"
			Digl.R.P.-G 2 -	750 x 5.9/3.0	5.75	"							655	"

Sheet 3

Powder No.	Gun	Calibre mm.	Powder		Charge wt. kgs.
			Type	Size	
16. 17. 18.	12.8 cm. Flak 40 {	128	Diql.R.P.-E H- or Diql.R.P.-HID- Diql.R.P.-S -	850 x 5.4/2.0 815 x 6.1/2.5 820 x 7.2/3.3	9.50 8.25
21. 24.	12.8 cm. Flak 40M {	128	R.P. 40M or R.P.-E-	850 x 6.5/2.5 815 x 6.1/1.8	10.0 10.0
+	12.8 cm. Flak 40 (increased velo'y	128	Gu.R.P.-E 2-	950 x . . .	14.0
31. 32.	12.8 cm. Pk 44 { (Tank destroyer)	128	Gu.R.P.-G 0.5-	820 x 5.4/2.5	15.1 12.0
6. 25a.	15 cm. S.K. 1/40 { (40 calibre)	149.1	R.P. 32 Lg.P. 40	550 x 4/2.5 550 x 5/2.3	10.34 8.50
6. 12. 13. 25a.	15 cm. Uty K 1/45 { (U boat gun)	149.1	R.P. 32 or R.P. 38 or R.P. 38M Lg.P. 40	550 x 4/2.5 535 x 6.5/2.8 535 x 7/3.1 550 x 4.5/2.0	8.64 8.50 8.30 7.95
6. 12. 25a.	15 cm. S.K. 1/45 {	149.1	R.P. 32 or R.P. 38 Lg.P. 40	825 x 4/3.5 825 x 7.5/3 825 x 5.5/3.5	14.25 " 9.50
6. 12. 25a.	15 cm. S.K. C/28 {	149.1	R.P. 32 or R.P. 38. Lg.P. 40	825 x 4/3.5 825 x 7.5/3 825 x 6.3/4.6	14.25 " 9.20
	15 cm. S.K. 1/55 {	149.1	as above	as above	as above

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Powder No.	Gun	Calibre mm.	Powder		Charge wt. kgs.	Shot wt. kgs.	Chamber		Shot travel mm.	Total cap. litres	Pressing		M.V. m/s	Projectile
			Type	Size			Length mm.	Cap. litres			Working kg/sq.cm.	Design		
12 6 25a	45 mm. S.A. G/25	149.1	R.P. 32 or R.P. 38 Lg.P.40	1150 x 10/4.4 1150 x 11/5.75 1150 x 8/6.4	19.1 " " 9.2	45.5 " " 41.0	1388 " " " "	27.7 " " " "	7174 " " " "	158.5 " " " "	3000 " " " "	3750 " " " "	980 " " 650	(H.E. 1/4.4 " " Star 1/4.3)
6 12 25a	15 cm. Wts KQ58 (torpedoboat gun)	149.1	R.P. 32 or R.P. 38 Lg.P.40	825 x 8/4.2 825 x 7.5/3 825 x 5.5/3.5	14.0 " " 9.5	45.5 " " 41.0	1150 " " " "	21.7 " " " "	5685 " " " "	123.2 " " " "	3000 " " " "	3500 " " " "	875 " " 650	H.E. 1/4.6 " " Star 1/4.3
1. 7.	s.I.G. 33 (heavy infantry gun)	150	1. Digl.B.P.-10.5- 2. " 3. " 4. " 5. " 6. "	3 x 3 x 0.8 " " " " " " " " " "	.172 .273 .390 .485 .578 .618	38.0 " " " " " " " " " "	80 " " " " " " " " " "	1.7 " " " " " " " " " "	1385 " " " " " " " " " "	- " " " " " " " " " "	1810 " " " " " " " " " "	2250 " " " " " " " " " "	129 157 180 216 237 247	H.E. 33 or 38 " " " " " "
26.			All above ch. wts. include .150 kgs. of Hgl. Bl.P.-12.5 - 40 x 40 x 0.2 Alternative charges for same velocities: 1. Gu.Bl.P.-A 0- 4 x 4 x 0.8 .194 2. " " " .305 3. " " " .439 4. " " " .545 5. " " " .633 6. " " " .877 All these alternative ch. wts. include .150 kgs. Digl. Bl.P.-10.5- 10 x 10 x 0.2											
7.	s.A.H. 16 (heavy howitzer)	150	1. Digl.Bl.P.-10.5- 2. " 3. " 4. " 5. " 6. " 7. Digl.Bg.P.-10.5- 8. "	4 x 4 x 1.2 " " " " " " " " " " 1.9 x 15/4 " "	.615 .740 .870 1.085 1.395 1.870 2.810 5.605	43.5 " " " " " " " " " " " " " "	364 " " " " " " " " " " " " " "	7.22 " " " " " " " " " " " " " "	3761 " " " " " " " " " " " " " "	75 " " " " " " " " " " " " " "	2500 " " " " " " " " " " " " " "	2920 " " " " " " " " " " " " " "	216 237 258 288 330 386 448 525	H.E. 19 or 19 Eo (anti- concrete)
7.			All charges are composite, wts. of Ch. 1 to 6 include .550 kgs. Hgl.Bl.P.-12.5- 40 x 40 x 0.2, and wts. of chs. 7 and 8 include .440 kgs. Digl.Bl.P.-10.5- 5 x 3 x 0.8.											

Powder No.	Gun	Calibre mm.	Powder		Charge wt. kgs.	Shot wt. kgs.	Chamber		Shot travel mm.	Total cap. litres	Pressure		M.V. m/s	Projectile
			Type	Size			Length mm.	Cap. litres			Working kg/sq.cm.	Design kg/sq.cm.		
22.	s.P.H. 18 (Heavy Howitzer) (cont'd.)	150	Alternative charges for the same velocities.											
	1. Digl.R.P.-10.5-		10 x 10 x 0.2	.710	} including .010 kgs. N.P.									
	2. Cu.Bl.P.-4 0-		8 x 8 x 0.9	.840										
	3. "		"	.895		} including ch. 1.								
	4. "		"	1.223										
	5. "		"	1.535										
	6. "		"	1.995										
	7. Digl.R.P.-6 0-		280 x 3/1.2	3.855	} including .075 kgs. N.P.									
8. "	"	4.805												
18.			Special ch. for rocket shell.											
18.			Digl.R.P.-G 1-	380 x 3.2/1.3	5.800							535	R. Shell 19	
22.	15 cm. K. 18 and 15 cm. (KH T) (cassette & tour)	150	Digl.R.P.-G 1-	530 x 3.2/1.3	8.0	43.0	1270	24.0	6584	144	3000	3600	638	R.E. 18
	Digl.R.P.-G 2-		455 x 7.5/3.4	14.8								805	"	
	"		"	18.5								890	"	
7.	s.H.T. (Heavy howitzer for fortifications)		1. Digl.R.P.-10.5-	4 x 4 x 1.2	.85	43.5	505.5	10.1	4354.5	89.1	2700	3190	235	R.E. 19
			2. "	"	1.08								250	"
			3. "	"	1.19								270	"
			4. "	"	1.37	including .40 kgs. Ngl.Bl.P.-12.5- 40 x 40 x 0.2							298	"
			5. "	"	1.59								328	"
			6. "	"	2.13								368	"
			7. Digl.R.P.-G 1-	460 x 5.4/3	5.895								490	"
			8. "	"	7.575	including .075 kgs. Nz. Man. N.P. 1.5 x 1.5.							632	"
26.			Alternative charges for the same velocities.											
			1. Digl.R.P.-10.5-	10 x 10 x 0.2	.87	including .10 kgs. N.P.								
			2. Cu.Bl.P.-4 0-	8 x 8 x 0.9	.96	} including ch. 1.								
			3. "	"	1.11									
			4. "	"	1.30									
			5. "	"	1.535									
			6. "	"	2.075									

Pouch No.	Gun	Calibre mm.	Powder		Charge wt. kgs.	Shot wt. kgs.	Chamber		Shot travel mm.	Total Cap. litres	Pressure		M.V. m/s	Projectile
			Type	Size			Length mm.	Cap. litres			Working kg./sq. cm.	Design		
23.	17 cm. K. L/50		Ms. M.P.	1.5 x 1.5	.08		1852.4	42.0	6448	186.6	3200	3750	635	H.E. 39 wt. 68 kgs.
23.			Digl. R.P.-G 2-5	660 x 34.6/30	.25	Main charge, total wt. 19.08 kgs.								
				660 x 7.6/3	18.75									
23.			Ms. M.P.	1.5 x 1.5	.04	Fore charge 3, total wt. 9.70 kgs., fired with main charge to give ch. wt. 28.78 kgs. and velocity								755
			Digl. R.P.-G 2-5	660 x 66.6/65	.54									
				760 x 7.4/3	9.12									
			Digl. R.P.-G 2-5	660 x 7.4/3	1.75	Fore charge 4, put in central tube of fore charge 3 to increase velocity in worn gun.								
22.			Ms. M.P.	1.5 x 1.5	.10	Special charge 1, total wt. 15.5 kgs., fired with main charge to give ch. wt. 34.58 kgs. and velocity								875
			Digl. R.P.-G 2-	980 x 7/4.2	15.40	Special charge 2 wrapped round special charge 1 to give total charge wt. 38.98 kgs. and velocity								940
			Digl. R.P.-G 2-	980 x 7/4.2	4.4									
6.	17 cm. S.K. L/40	172.6	R.P. C/32	1040 x 10/4.8	22.5	64.0	1304	32.5	5067.5	152.5	2930	3800	850	A.P. L/3 or H.E. L/3 or L/3.3 (both loose fuzes.)
12.			R.P. C/38	1040 x 9.5/3.8	23.5	62.8							875	H.E. L/4.7
20.			Lg.P.40	1048 x 7.5/5.2	14.15	58.7							690	Star L/3.7
6.	20.3 cm. C/34a	203	R.P.C/32	835 x 12/5	43.55	122	1882	70.3	9645	380.6	3200	3700	925	-
26a			or R.P.38		43.0									
			Lg.P.40	835 x 5/2	27.0								700	
These charges contain small amounts of other stick lengths which are included in the ch. wt.														
4.	21 cm. S.K. L/45	209.5	R.P.C/12	845 x 12/5		108	1302	48.9	7524	313.7	3400	3800	900	(A.P. L/2.9
6.			or R.P.C/32	845 x 9/3.75		Or with small Service charge velocity								800
12.			or R.P.C/38	845 x 9/3.0										
There are also reduced charges for velocity 800 m/s.														
														(L/2.9 or (H.E. L/4.5 (of wt. (113.5 kgs.

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Sheet 13

Powder No.	Gun	Calibre mm.	Powder		Charge wt. kgs.	Shot wt. kgs.	Chamber		Shot travel mm.	Total cap. litres	Pressure		M.V. m/s	Projectile
			Type	Size			Length mm.	Cap. litres			Working kg/sq.cm.	Design		
6.	28 cm. S.K. L/50 or long Bruno K (R) (Railway mounting)	283	R.P. 32	1230 x 14/6.7 820	104.5	302	2192	150	11229	974.2	3100	4400	845	(A.P. L/3.2 (or H.P. L/3.4)
12.			or R.P. 38	1230 x 14/6 830	105.5									
13.			or R.P. 38M	1190 x 14.8/4.9 820	111.0									
6.	28 cm. S.K. Q/28	283	R.P. 32	1230 x 15.5/6.9 970	100.6	300	2333	180	11572	907.9	3300	3700	910	(H.P. L/4.2 (or A.P. L/3.7)
12.			or R.P. 38	1230 x 14/7.2 970	105.2									
6.	28 cm. S.K. Q/40 or short Bruno K (R) (Railway mounting)	283	R.P. 32	1230 x 10/4.7	65	240	1842	122.8	8558	670.8	3100	3300	820	A.P. L/2.6 or H.P. L/4.3 or H.E. L/4.1
12.			or R.P. 38	1230 x 11/5.1	67									
24.	K-5 (50 Km. range)	280	Digl. R.P.-G 5 -	820 x 12.7/5.6	165	255	2943	240.0	17607	1371.6	3200	3750	990	H.E. 35
			or plus "	300 x 12.7/5.6	21									
This gun also fires a rocket shell with M.V. of 1120 m/s but a range of 85 Km.														
24.	Bruno H.K.	280	Digl. R.P.-G 5 -	710 x 13/5.2 810	186	285	2766	229.7	12800 approx	1040.9	3200	3700	960	H.E. L/4.4
6.	30.5 cm. S.L. L/50	305	R.P. 32	1230 x 14/6.7 1240	(122.4 142.4	405 250	2528 2493	199.3 197.5	11933 11968	1093.8 "	3000 3350	3900 "	855 1120	H.E. L/3.8 or A.P. H.E. L/3.6
12.			or R.P. 38	1230 x 18/8 1240	(123 143	405 250	2528 2493	199.3 197.5	11933 11968	" "	3000 3350	" "	855 1120	H.E. or A.P. L/3.4 H.E. L/3.5

Sheet 14

Powder No.	Gun	Calibre mm.	Powder		Charge wt. kgs.
			Type	Size	
22.	M. 1	{ 350	1. Digl.R.P.-G 2-	800 x 5/3	33.4
			2. "	"	43.4
			3. "	"	60.4
23.			4. Digl.R.P.-G 2.5-	1000 x 9.6/5	93.4
6.	38 cm. S.K. C/34	{ 380	R.P. 32	850 x 16.4/6.8	200
12.			or R.P. 38	850 x 17/7	208
32.	Siegfried K. (Coast defence)	{ 380	Gu. R.P.-G 5-	820 x 10.5/3.5	300
				1300	253
					261
32.	Adolf K. (Coast defence)	{ 406.4	Gu. R.P.-G 5-	1220 x 10/3	350
				885	307
9.	Canon Mrs (Heavy mortar)	{ 420	1. Digl.R.P.-G 5-	550 x 13/5	52.5
			2. "	"	58.3
			3. "	"	65.8
			4. "	"	77.8
	Gerat 36	533.4	Gu. R.P.	-	800
32.	s. Gustav	{ 800	Gu. R.P.-G 5-	1510 x 25/12	1500
				1580	1630
					1800
					2000

Shot wt. kgs.	Chamber		Shot travel cms.	Total ocp. litres	Pressure		M.V. m/s	Projectile
	Length cms.	Cap. litres			Working	Design		
575	1603	168.5	7997	939	2500	3000	340 402 480 582	Anti-con-
All ch. wts.		include .4 kgs. N.P.		1.5 x 1.5.				
800	2230	319	16175	2204	3200	3700	820	
495	2479	361.7	15926	2217	3200	3700	1050	Light proj.
495	"	"	"	"	"	"	920	"
800	2464	360	15941	"	3000	"	820	Heavy proj.
670	2676	460	17074	2732	3200	3650	1050	Light proj.
1030				"	3100	"	810	Heavy proj.
1020	909	135	5431	911	2800	3050	342 305 412 465	Heavy anti-concrete
All ch. wts.		include .3 kgs. R.P.		1.5 x 1.5.				
2200	4366	1250	21674	6211	3000	3420	820	
7000	4748	3400	27352		-	3000	600	anti-concrete
"	"	"	"		-	"	650	
"	"	"	"		2500	"	710	
4750	"	"	"		2600	"	850	