Naval Propellants - A Brief Overview

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All percentages in this essay are in terms of the total charge weight.

British Propellants

Cordite Propellants

Cordite was widely used by the British with **Mark I** being the first version produced, with manufacturing starting in 1889. This propellant was much more powerful and thermally efficient than gunpowder or brown powder, as shown by tests with early British 6 inch (15.2 cm) QF guns. These guns replaced their 55 lbs. (25 kg) charge of brown prismatic powder with only 13 lbs. (6 kg) of the new Mark I cordite propellant. Mark I cordite consisted of 37% nitrocellulose (13.1% Nitrogen), 58% nitroglycerine and 5% petroleum jelly. This last ingredient had originally been used as a lubricant during the manufacturing process, but it was found that it also acted as a stabilizer as its unsaturated hydrocarbons counteracted the byproducts of the decomposition process.

As can be easily guessed by the name, Cordite was primarily manufactured in thin cylindrical or cord form, with the different sizes denoted by a number representing the hole diameter of the extrusion die. For Mark I cordite, these numbers were in 0.010 inch (0.254 mm) increments. For example, **Cordite 30** meant Cordite Mark I extruded through a die having holes 0.300 inches (7.62 mm) in diameter. It should be noted that using propellant in cord form means that the burning surface decreases as the propellant burns and that with hindsight it would have been better to adopt a tubular form, as was done in Germany. Tubular forms have a constant burning surface and thus produce more gas to fill the expanding volume as the projectile travels up the barrel.

Cordite Mark I was first issued for 3-pdr, 6-pdr, 4.7-inch and 6-inch guns in 1893 and for 12-inch guns in May 1895. Generally, the larger the gun, the larger the cord sized used. For example, the 12" (30.5 cm) Mark VIII and IX guns used **Cordite 50**, the 6" (15.2 cm) guns used **Cordite 30** and the Hotchkiss 3-pdr guns used **Cordite 5**.

Mark I cordite did burn very hotly and this was found to be detrimental to gun barrel life, as the high temperatures caused rapid wear. For this reason, the proportions of nitroglycerine and nitrocellulose were revised in order to increase the barrel life. This new propellant was designated **MD** (for Modified) and it came into service in 1901. MD cordite consisted of 65% nitrocellulose (13.1% N), 30% nitroglycerine and 5% petroleum jelly. MD charges were about 25% heavier than Mark I for the same ballistic result but doubled the life of the guns. MD did have a high shrinkage rate during the drying process, with cords that were extruded at 0.45 inches (1.14 cm) in diameter shrinking down to as little as 0.34 inches (0.86 cm) after they dried. A tube form was made for at least the 4-inch (10.2 cm) QF Mark III, but most guns still used the cord form. Like Mark I cordite, the different sizes of MD were denoted by a number representing the hole diameter of the extrusion die and the numbers were in 0.010 inch (0.254 mm) increments. The most common sizes were **MD4.5**, which was used for 3-pdr guns, **MD8**, **MD11**, **MD19**, **MD26**, **MD37**, which was used for 9.2-inch (23.4 cm) guns and **MD45** which was used for the 12-inch (30.5 cm) and larger guns. A larger diameter **MD55** cord was tried as this would have been advantageous for the larger caliber guns, but it was found to be impossible to remove all of the volatile solvent.

Both Mark I and MD were in use during World War I, and both had poor storage characteristics with their stability degrading over time. A study performed after World War I found that MD tended to form highly unstable micro-sized dust particles consisting of nitrocellulose and iron pyrites. These unfortunate traits led to several ships suffering magazine explosions during World War I, both in action and in harbor.

By April 1917 considerable improvements had been made in the manufacture of cordite by changing to the use of clean carded sliver cotton, substituting cracked mineral jelly for petroleum jelly, using guncotton which had been nitrated for a minimum of 2.5 hours and in using inspectors for quality control at all stages of the process. This improved propellant was known as **MC** (for Modified Cracked) and the substitution of cracked mineral jelly in place of petroleum jelly was in a bid to improve stability. With this exception, MC cordite was chemically similar to MD cordite. Plans were put in place during the spring of 1917 to replace some 6,000 tons (6,100 mt) of old cordite with MC cordite as soon as production permitted. However, after the battleship Vanguard exploded in harbor in July 1917, this program was expedited and the exchange was completed in ships of the Grand Fleet by March 1918 and in all ships by September 1918. MC cordite was a fairly satisfactory propellant if properly and carefully made and it was still in use during World War II, primarily as an alternative propellant for certain guns.

In 1927, following a study of the German **RP C/12** solventless propellant (see below) used during World War I, British chemists developed a more stable version of cordite called **SC** (solventless cordite, also known as solventless carbamite). This was used to replace the older propellants as rapidly as possible and remained in service until well after World War II. SC was primarily manufactured in cords (strings) but some was also made in tubular form. The nomenclature was changed such that the cord die hole diameter was now given in 0.001 inch (0.0254 mm) increments. SC consisted of 49.5% nitrocellulose (12.2% N), 41.5% nitroglycerine and 9% centralite (also known as "carbamite"), which was used as a stabilizer. Centralite not only improved the stabilization of SC cordite, it did not have to be removed during the manufacturing process, which gave it better dimensional stability as well. This also permitted the use of larger diameter cords, with the largest being **SC500** which was used for the 14-inch

Mark VII guns at Dover for cross-channel firings. However, SC was a stiff material to extrude and needed much higher pressures than did the Cordite MD type.

A hotter burning propellant known as **HSC** (for Hot Solventless Carbamite) or **HSCT** (for Hot Solventless Carbamite Tubular) for 6-pdr, 3-pdr and 2-pdr guns was also produced. This was composed of 49.5% nitrocellulose, 47% nitroglycerine and 3.5% centralite.

SC was used extensively during World War II and had a better safety record than the previous cordites, although the loss of HMS Hood may be partially attributed to it.

Nitrocellulose Propellants

Nitrocellulose propellant imported from USA sources in flake or tube form was standard for Oerlikon 20 mm guns during World War II. In addition, the USA DuPont chemical company **NH** and **FNHP** propellants of nitrocellulose dinitrotoluene type in multi-tube form were extensively used for guns between 4 inch (10.2 cm) and 5.25 inch (13.3 cm). The short multi-tube grains of these propellants were particularly well-suited for bottle-neck cases such as those used for the 4.5 inch (11.4 cm) guns. NH was composed of 86% nitrocellulose (13.15% N), 10% dinitrotoluene, 3% dibutylphthalate, 1% diphenylamine while FNHP differed in having 2% less nitrocellulose and 2% more dibutyl phthalate with 0.8% potassium sulfate. FNHP was commonly used for Bofors 40 mm cartridges.

Flashless Propellants

Due to the presence of calcium in the small amount of chalk used to counteract traces of residual acids, SC cordite had a very bright "flash," a characteristic which led to the development of flashless propellants. British flashless propellants in use during World War II were produced in primarily in slotted tubular form. The most used was **NF**, originally known as **NFQ**, and this was composed of 55% picrite (nitroguanidine), 16.5% nitrocellulose (12.1% N), 21% nitroglycerine, 7.5% centralite and 0.3% cryolite. NF was not easy to make and the basic initial material required for picrite was calcium carbide, which required large amounts of electricity during the manufacturing process. For this reason, the only plant making this propellant was located at Welland near Niagara Falls in Canada. Canada also produced **Cordite N** during World War II which was widely used as a propellant for aircraft gun ammunition. Cordite N is another triple-base propellant that was very cool burning and produced little smoke and almost no flash. The composition was 55.0% nitroguanidine, 19.0% nitrocellulose, 18.5% nitroglycerin and 7.5% ethyl centralite. Cordite N does not appear to have been used as a naval gun propellant in the Royal Navy, but a variation of it was used by the USN (see below).

Flashless propellant was in great demand during the war, however, for guns larger than 5.25" (13.3 cm), full flashless charges became too bulky for existing turret arrangements and so the only larger weapon issued these was the 6" (15.2 cm) Mark XXIII. These were actually "reduced flash" or "non-blinding" charges and were designated as **NQFP**.

This propellant was issued in cord form and differed from NF by having 4.5% more nitrocellulose, 4.5% less centralite and 2% potassium sulfate.

Modern Propellant

The 114 mm (4.5") Mark 8 naval gun uses a triple-base (Nitroguanidine, Nitroglycerin and Nitrocellulose) flashless propellant known as MNLF/2P/M08. This is manufactured in tube form.

Other Propellants

Notable among British double-base propellants was **CSP_2** (for Chilworth Special Powder No. 2) made by the Chilworth Gunpowder Company prior to World War I. This propellant was widely used by the armament firm of Elswick for many of their export weapons as an alternative to cordite. CSP_2 consisted of 70.5% nitrocellulose, 23.5% nitroglycerine, 5% petroleum jelly and 1% sodium bicarbonate. After 1910, this propellant was also manufactured by the Nobel Dynamite Company of Avigliana, Italy.

British Nomenclature

As noted above, British cordite propellants were designated by the type and a number representing the hole diameter of the extrusion die. For Mark I, MD and MC formulations, these numbers were in 0.010 inch (0.254 mm) increments and for SC cordite they were in 0.001 inch (0.0254 mm) increments. For example, **MD45** meant MD-type cordite manufactured with dies having 0.450 inch (11.4 mm) diameter holes while **SC350** meant SC-type cordite manufactured with dies having 0.350 inch (8.89 mm) diameter holes.

Propellant grains made in the form of tubes were designated by the type of propellant followed by two numbers, with the first number indicating the external diameter and the second the internal diameter, both in 0.001 inch (0.0254 mm) increments. SC in tubular form was designated in the form of **SC T 100-40**. HSC and HSCT designations were in the form of **HSCT/K 134-055** with the **K** indicating that potassium cryolite was used as a moderator. NF designations were of the form **NF 164-048**.

French Propellants

Poudre B

The first "smokeless powder" propellant was invented by the French chemist Paul Vielle in 1884 and adopted by the Navy around 1890. Known as **Poudre B** (for Poudre Blanche, meaning "white powder"), this was a single-base propellant composed primarily of nitrocellulose. This early French nitrocellulose was susceptible to spontaneous ignition, and is believed have caused the loss of the battleships Liberté and Iéna, but this propellant was improved by the addition of diphenylamine as a stabilizer and by more careful attention to the pulping and cleaning process to remove residual traces of acid. The French continued to use single-base nitrocellulose in a strip form for most of their weapons up to World War II. These propellants were designated as **BM** (for Blanche Modifié? - Modified White?) followed by a number which indicated thickness, such as **BM15**. This number was somewhat arbitrary, but a larger number did indicate a thicker strip. During the war, BM was produced in a reduced flash version using potassium chloride for some 138.6 mm guns.

Solventless Propellants

French "solventless" propellant designated as **SD** was produced during the 1930s for a few guns including the 380 mm and 330 mm. Like British SC, French SD appears to have been developed from a study of German RP C/12, as it was in the form of a single tube grain and the composition was similar in its proportions of nitrocellulose, nitroglycerin and centralite. The actual composition of SD was 64-65% nitrocellulose, 25% nitroglycerin and 8-9% centralite. Like BM, the SD designation was followed by an arbitrary number with a larger number indicating a larger grain size. SD_{19} was issued for 330 mm guns while SD_{21} was issued for 380 mm guns. The grain for SD_{19} was 14 mm (0.55 in) outside diameter and 4 mm (0.157 in) internal diameter. The grain for SD_{21} was a larger tube, but the dimensions are unavailable at this time.

German Propellants

German propellants for the first half of the twentieth century were manufactured in the form of hollow tubes and designated as **RP** for Rohr-Pulver or "Tube powder." The propellants were classified by model year and by the external and internal diameters of the tubes in millimeters. For example, **RP C/38 (14/4.9)** meant a tube powder first introduced in 1938 that had an external diameter of 14 mm (0.551 in) and an internal diameter of 4.9 mm (0.193 in).

Prior to 1912, the Germans used solvents in their manufacturing process, including for **RP C/06**, the standard propellant in use prior to World War I. There were several compositions used between 1912 and 1945, all of a solventless double-based nature using centralite (symmetrical Diethyl Diphenyl Urea) as a non-volatile solvent. Centralite was not removed from the finished propellant and acted as an excellent stabilizer. Leaving this solvent in also greatly reduced shrinkage during the drying process.

The first of these solventless propellants, **RP C/12**, was the primary propellant used during World War I. This and **RP C/32** used nitroglycerin while formulations starting with **RP C/38** used diethylene glycol dinitrate (DGN), which was cooler-burning and less bore erosive. All of these formulations were resistant to exploding even when exposed to a hot fire. For instance, when the small battleship Gneisenau was bombed at Kiel in 1942, over 23 tons (24 mt) of RP C/32 propellant was ignited in a forward magazine. There was no explosion even though the 750 mt (738 ton) turret "Anton" was lifted at least 50 cm (20 inches) from its mounting by the gas pressure generated by the deflagration. As noted above, both the British and the French did extensive studies of RP C/12 after World War I and developed their own "solventless" propellants based upon the results.

Chemical Compositions

RP C/06 - 70.5% nitrocellulose (about 12% N), 23.5% nitroglycerine, 5% petroleum jelly, 1% sodium bicarbonate.

RP C/12 - 64.13% nitrocellulose (11.9% N), 29.77% nitroglycerine, 5.75% centralite, 0.25% magnesium oxide and 0.10% graphite.

RP C/32 - 66.6% nitrocellulose (11.5% N), 25.9% nitroglycerine, 7.25% centralite, 0.15% magnesium oxide and 0.10% graphite.

RP C/38 - 69.45% nitrocellulose (12.2% N), 25.3% DGN, 5.0% centralite, 0.15% magnesium oxide and 0.10% graphite.

RP C/38N - 68.72% nitrocellulose (12.2% N), 25.03% DGN, 1.5% centralite, 4.5% methyl centralite, 0.15% magnesium oxide and 0.10% graphite.

RP C/40 - 67.55% nitrocellulose (11.45% N), 24.6% DGN, 7.5% centralite, 0.25% magnesium oxide and 0.10% graphite.

RP C/40N - 64.87% nitrocellulose (12.2% N), 23.63% DGN, 0.5% akardite, 7.0% methyl centralite, 0.15% magnesium oxide and 0.10% graphite.

Italian Propellants

Italian propellants before World War II were designated as **C** and were typically a mixture of 68.5% nitrocellulose, 25.5% nitroglycerine, 5% petroleum jelly and 1% sodium bicarbonate. This propellant was apparently derived from Elswick **CSP_2** and was chemically similar to the German RP C/06. In 1936 solventless propellants were introduced with **NAC** from Dinamite Nobel and **FC_4** from Bombrini-Delfino. NAC contained 66% nitroacetylcellulose (this was nitrocellulose mixed with a small amount of acetyl cellulose), 27% nitroglycerine and 7% centralite. FC_4 was 64% nitrocellulose, 28% nitroglycerine, 4% phthalit, 3% centralite and 1% petroleum jelly. Grains were usually of single tube design, although the charges for the 381 mm/50 (15 inch) guns also had a disk propellant at the igniter end, possibly to speed up the charge ignition. Reduced flash propellants were introduced during the war by the addition of potassium chloride with charges being produced for gun calibers between 12 cm (4.7 inches) and 20.3 cm (8 inches).

Postwar, the Italians have adopted a singe-based propellant similar to the USN's NACO (see below). These are designated with **M** numbers, such as M8 or M10.

Japanese Propellants

Before 1893 the Japanese Navy used brown prismatic powder which was purchased from Britain, Holland or Belgium. In 1888, the Japanese Army, which was responsible for procuring propellants both for itself and for the Japanese Navy, tested the French Poudre B propellant. The tests results were acceptable, and the Japanese purchased a production plant in 1893.

British Mark I Cordite was introduced to Japan the same year when the British-built cruiser Yoshino entered service. On 19 March 1903, Cordite Mark I, which the Japanese designated as **C** and called *Jinjô Chûjô* ("common cord like powder"), was adopted for all QF-type guns then in service with the Navy.

Until after the Russo-Japanese War, all naval propellants were imported but in 1907 the Japanese let a contract to the Sir William Armstrong Co. to build a factory at Hiratsuka City, Kanagawa Prefecture, for the manufacture of British **MD** cordite. The plant was completed in December 1908 and produced both **MDC** cords and **MDT** tubular propellant. In 1919, the Japanese Navy purchased this factory outright and renamed it the *Kaigun Kayakukô* (Naval Powder Plant).

In 1912, the Japanese developed and produced their first naval propellant, known as $\mathbf{C_2}$ for Type 2 Cordite. Officially adopted on 12 September 1917, this consisted of 65% nitrocellulose, 30% nitroglycerine, 3% mineral jelly and 2% *jara jara* (beta naphthol methyl ether). This propellant was also made in a tubular form (tubite) and in this form was known as $\mathbf{T_2}$. In 1920, centralite was introduced as a gelatinizer, a technique used by the Germans in their RP C/12. By 1924, this had become the standard naval service propellant and was known as **DC** (for *Doku* = Deutsch or German Cordite).

Flashless

Fairly satisfactory flashless propellant containing potassium sulfate and hydrocellulose was introduced about 1938. Known as **FD**, this was said to reliably eliminate flash for guns up to 14 cm (5.5 inch) but not for larger guns.

Nomenclature

The nominal diameter of the Japanese cords was given in units of 0.1 mm (0.004"). For example, the Japanese propellant **80DC** was cordite with cords of 8.0 mm (0.315") diameter.

ROCKET AND GUN PROPELLANTS USED BY JAPANESE NAVY

Symbol and Name		Composition															Characteristics							
		N/G	G/C	M/C	C/C	C/L	OTU	M/J	J/J	MNN	H/C	GP	M/M	K_2SO_4	Sn	Na/B	Colorific Value (Q) (KCal)	Explosion Temperature (°C)	Specific Volume (cc)	Force of Explosion (kg-dm)	Abel's Heat Test (min)	Silvered Vessel Test (hr)	Volatile Matter (%)	Color
C	Common Cordite	58	37					5									1212.9	(gas)3731	881.5	12450	30.0	200	0.3	Light brown
C_2	Type 2 Cordite	30	65					3	2								1012.7	3250	917.5	11290	20.0	1200	1.65	Light brown
T_2	Type 2 Tubite	30	65					3	2								1012.7	3250	917.5	11290	20.0	1200	1.65	Light brown
DC	Type 13 Cordite	30		64.8		4.5							0.7				931.8	3033	928.7	10660	14.48	800	1.0	Grayish black
DT	Type 13 Tubite	30		64.8		4.5							0.7				931.8	3033	928.7	10660	14.48	800	1.0	Grayish black
DB	Type 13 Lameller	30		64.8		4.5							0.7				931.8	3033	928.7	10660	14.48	800	1.0	Grayish black
C_3	Type 89 Cordite	26.5	68.5						5								1015.4	3305	898.3	2800	6.0	1800	1.5	Light brown
T_3	Type 89 Tubite	26.5	68.5						5								1015.4	3305	898.3	2800	6.0	1800	1.5	Light brown
F_2	Type 90 mk 2 Cordite	15			68		8				8					1	465.8	1680	1071.5	6810	27.4	6006	1.7	Light yellow
C_4	Type 92 Cordite	40	55			3	2										1128.4	3590	972.7	11850	20.0	1200	0.3	Light yellow-brown
T_4	Type 92 Tubite	40	55			3	2										1128.4	3590	972.7	11850	20.0	1200	0.3	Light yellow-brown
DC_1	Type 93 mk 1 Cordite	41		51.8		4.5	2						0.7				964.2	3137	922.5	10950		800	0.6	Greyish black
DC_2	Type 93 mk 1 Cordite	27		64.3		5	3						0.7									900	1.0	Greyish black
DC_3	Type 3 Cordite	33		60.0		6.5						0.1			0.4							1060	0.89	Greyish black
DT	Type 93 mk 1 Tubite	41		51.8		4.5	2						0.7				789.0	2640	978.1	9770		800	0.6	Greyish black
DT_2	Type 93 mk 2 Tubite	27		64.3		5	3						0.7									900	1.0	Greyish black
TT_2	Toku	27		64.3		5	3						0.7	3								1135	3.1	Greyish black
FD	Toku	26.4		53.4		7.2#					6.0	0.09					984.2	3137	922.5	10950		3642	1.0	Greyish black
FD_1	Toku	27.5		55.6		7.6#																3529	1.0	Greyish black
T_6	Toku	30		60		3.0				7.0							652.9	2260	938.8	8288		963	2.88	Yellow-brown
FDT_6	Toku*	27		60		3.0*				7.0												863	2.39	Yellow-brown
FD	Type 2 mk 1	30		61.3		5	3				8		0.7	8										Flameless
FD_1	Type 2 mk 2	30		65.3		5	3				8		0.7	4										Flameless

* Used in rockets.
\# This value denotes total per cent of C/L and OTU combined.
Editor's note: Information in the lower right quarter of above table is possibly in error due to misalignment of original.

N/G Nitroglycerin
G/C Gun Cotton
M/C Mixed Nitrocellulose
C/C Colloidion cotton

C/L Centralite
OTU Orthotolylurethane
M/J Mineral Jelly
J/J Jalajala or jara jara

MNN Mononitronaphthalene
H/C Hydrocellulose
M/M Mineral Matter
Na/B Sodium Bromide

Table from "Report O-10-2: Japanese Propellants - Article 2, Rocket and Gun Propellants - General"

United States of America Propellants

Smokeless Powder

By 1896 the USN had begun small-scale production of a single-base nitrocellulose propellant at Newport, Rhode Island. Major manufacturing of this "smokeless powder" **SP** at the Naval Ordnance Station (later known as the Naval Powder Factory), at Indian Head, Maryland was begun in 1900 and continued there for decades.

Smokeless powder will deteriorate over time as it contains nitrocellulose and two volatile substances, ether and alcohol. Its length of usefulness depends largely on the conditions under which it is stowed. Moisture or heat speeds its deterioration and the combination of the two is extremely damaging to the propellant. In 1905, George Patterson, the key civilian researcher at Indian Head, was experimenting with the addition of rosaniline dye to the propellant, designating these lots as **SPR**. This dye did nothing to stabilize the deterioration of the propellant, but instead showed the status of the deterioration by changing color as it combined with the forming acids.

Patterson recommended the abandonment of rosaniline dye in 1908 in favor of adding diphenylamine as a stabilizer. Known as **SPD**, this new propellant was first produced in 1908 and adopted as the standard propellant formulation by 1912. SPD was found to have good stability characteristics when properly stored, with some lots manufactured prior to World War I staying in storage for as long as twelve years without loss of stability. During World War II, the primary USN propellant was SPD in a multi-tube form made up of 99.5% nitrocellulose (12.6% N), 0.5% diphenylamine. The USN used a flat, short cylindrical grain design that usually had seven perforations with the websize varying from 0.023 in (0.58 mm) for the short 3 in (7.62 cm) gun to about 0.174 in (4.42 mm) for the 16 in (40.64 cm) guns. SPD had a good safety record partly due to the harder-to-ignite and slow burning nature of its single-base nature and partly due to the quality of its manufacturing process.

Flashless Propellants

In the mid-1920's, both the Naval Powder Factory at Indian Head and the DuPont Co. developed flashless powders. The Powder Factory had also obtained good results by mixing flash-reducing chemicals with the conventional powder charge. Flashlessness, however, was gained only by an increase in the amount of smoke, which was unacceptable to the fleet as it interfered with searchlight illumination and fire control. By 1928, BuOrd had stopped work on flash suppression. With the advent of radar in World War II, smoke became less objectionable and the fleet was willing to accept considerably more smoke in order to obtain a significant reduction in flash. At the time the request for flashless powder was received, BuOrd had already accumulated large inventories of smokeless powder. In order to prevent this material from being discarded, some means of converting it into acceptable flashless charges had to be found.

By the summer of 1942, the Naval Powder Factory had the answer in a chemical tablet made of a mixture of potassium nitrate and potassium sulfate, to which was added a small amount of graphite to facilitate pelleting. After extensive testing by the Naval Proving Ground had worked out the details, production was begun in September 1942. The use of these flashless pellets was limited to guns between 3 to 6 inches (7.62 to 15.2 cm) as larger calibers would have required too many pellets. Even in these calibers performance was not always perfect. A fused mass of clinkers could form in the gun chambers, a result of incomplete combustion of the pellets. At high angles of gun elevation, these clinkers could cause gun casualties such as jammed breech mechanisms. To eliminate the hazard, the Research Division of BuOrd, working with the Naval Powder Factory, developed a flashless grain. Known as **SPDF**, this new material consisted of 5 to 7 percent potassium sulfate mixed with nitrocellulose, colloided as a normal smokeless powder, and extruded in the form of a powder grain. Satisfactory in both ballistic and flash suppression properties, flashless grains of this type were in production at the Naval Powder Factory when the war ended. Meanwhile, pellets continued to serve the need for a flash suppressor for existing propellants. While not completely satisfactory, these two compositions provided the fleet with an essentially flashless charge long before it was possible to have true flashless powder.

During World War II some **Cordite N** (see above) flashless propellant was imported from Canada and this was used for full charges for at least 6 inch (15.2 cm) and 8 inch (20.3 cm) guns and in reduced charges for 16 inch (40.6 cm) guns during the war and for other guns afterwards. Known as **SPCG** in USN service, the composition of this propellant differed from British NF and consisted of 19.0% nitrocellulose (13.1% N), 18.7% nitroglycerine, 55% nitroguanidine and 7.3% centralite. BuOrd was unhappy with this propellant, as Cordite N was brittle and, even worse, it contained nitroglycerine, which the USN considered to be highly undesirable for use in naval propellants. BuOrd instituted a major research program to develop a flashless propellant that did not use nitroglycerine. After testing dozens of possibilities, scientists narrowed the field to two likely candidates - dinitrodiethanol nitramine (DINA) and Fivonite. Experimental firing at Dahlgren showed little difference between the two, but DINA was selected because of its superior physical properties.

Albanite, the name given this new flashless powder because of its white color, appeared to have all the desirable features of Cordite N and few of the objectionable ones. Studies of Albanite by DuPont demonstrated the feasibility of large-scale production, and by V-J Day BuOrd had launched an ambitious procurement program which called for monthly deliveries of 4,000,000 pounds of the new propellant. Albanite was composed of 20.0% nitrocellulose (12.6% N), 19.5% DINA, 55.0% nitroguanidine, 4.0% dibutyl phthalate and 1.5% centralite. To this mixture was added a small amount of potassium sulfate and lead which acted as a decoppering agent. These charges weighed about 10% more than those for nitrocellulose.

Modern Propellants

In the early 1950s experiments with a solventless propellant known as **NOSOL** progressed into the current formulations of single-base propellant known as "Navy Cool" or **NACO** which is composed of 91% nitrocellulose (12.0% N), 1% ethyl centralite, 3% butyl stearate, 1% basic lead carbonate, 1% potassium sulfate and 3% volatiles.

The ERGM rocket projectile currently under development uses a special mixture known as **EX-99** propellant which, according to one open-source document, is composed of 76% RDX (cyclonite, cyclomethylene trinitramine), 12% cellulose acetate butyrate (CAB), 7.6% acetal/formal (A/F), 4% nitrocellulose and 0.4% ethyl centralite. The high percentage of RDX gives this propellant the unusually high "kick" necessary for this relatively heavy projectile and is one of the reasons why the 5"/62 (12.7 cm) gunhouse was greatly strengthened over the earlier 5"/54 (12.7 cm) gunhouse.

USN Designations

The designations below are normally followed by a number that indicates the sequence of manufacture. The combination of the letters and the number is termed the index or the lot of the powder.

- **SP** - Smokeless Powder, the original single-based propellant adopted by the USN around 1896
- **SPR** - Smokeless Powder with Rosaniline dye, in service with the USN for a brief period between 1905 and 1908
- **SPD** - Smokeless Powder with Diphenylamine as a stabilizer, adopted by the USN in 1908
- **SPDB** - A blend of diphenylamine stabilized powders of different lots. The purpose of blending is to provide a uniform index of ample size and desired characteristics from smaller remnant lots.
- **SPDF** - A flashless formulation of SPD
- **SPDN** - SPD with nonvolatile materials added to reduce its hydroscopic tendencies. The **N** stands for nonhygroscopic.
- **SPDW** - Reworked propellant intended for target use. Propellant is ground down, reprocessed and then made into new grains.
- **SPWF** - Reworked propellant to which a flashless element has been added
- **SPDX** - Water-dried SPD
- **SPC** - Smokeless Powder with Carbamite (ethyl centrality) added for stability
- **SPCF** - A flashless formulation of SPC
- **SPCG** - Flashless triple-based propellant stabilized with carbamite. The **G** is short for **NG**, the designation for Nitroguanidine.

Propellant Charge Weights for Bag Guns

Most non-official (and many official) published references for USN bag guns vary from each other by a few pounds (a couple of kilograms) as to the charge weights used by any particular bag gun. Primarily, this is because most official documents exclude the weight of the gunpowder used as bag igniters, but a few official documents combine the igniter weights with the actual SPD propellant weight. Complicating matters is that after World War II a cooler burning formulation of SP was adopted which resulted in slightly different charge weights.

For example, a full charge for the 16"/50 (40.64 cm) Mark 7 during the World War II period consisted of six propellant bags whose total propellant weight was 660.0 lbs. (299.4 kg) of SPD and 4.463 lbs. (2.1 kg) of gunpowder. Some references show this charge weight as 660.0 lbs. (299.4 kg) while others show it as 664.463 lbs. (301.4 kg). With the post-war adoption of the cooler burning propellant, the six bag full charge weight for this gun changed to 655.0 lbs. (297.108 kg) and 4.463 lbs. (2.1 kg) of gunpowder. Again, some references show this charge weight as 655.0 lbs. (297.108 kg) while others show it as 659.463 lbs. (299.2 kg). For the most part, on my datapages I list only the actual propellant weight without the igniter gunpowder as shown in *U.S. Explosive Ordnance: Ordnance Pamphlet 1664* which I have found to be reliable for the World War II period.

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