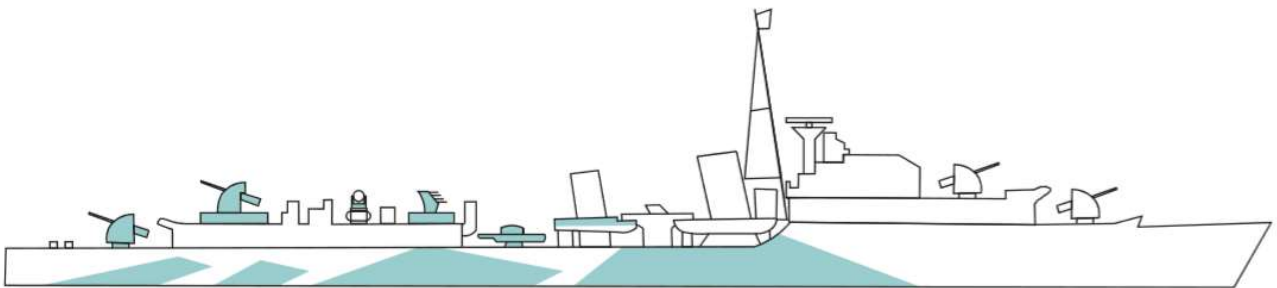
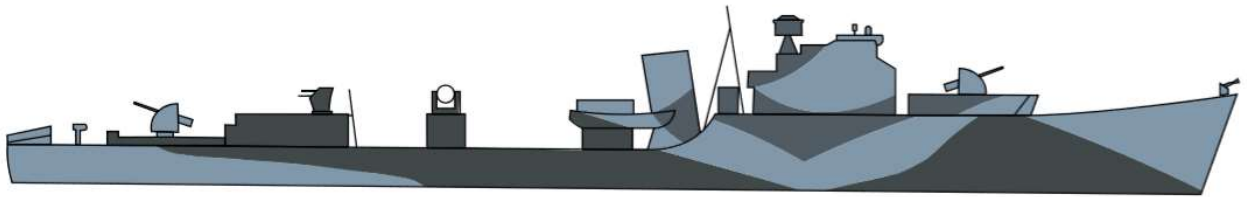


Royal Navy Colours of World War Two B & G Series Camouflage Colours 1943-1945



James Duff

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Introduction

In the final months of and in the years after World War Two, many resources, documents and records relating to Royal Navy camouflage were purposely destroyed. That there might have been future value in these resources was either not recognized or deemed unimportant. In the decades in between then and now, several researchers have attempted to piece together from old samples, eye witness accounts and photographic records, a view on what the Royal Navy's colour palette was during the years 1939 to 1945. The author's motivation for writing this work stems from trying to reconcile contradictions in extant references and various anachronisms evident both in other published works and common belief as compared to formal documentation.

This work deals with the paints G5, G10, B15, G20, B20, B30, G45 and B55 used by the Royal Navy which, along with white, comprised the complete colour palette from April 1943 until the end of the second world war.

All colour measurements made in the preparation of this paper were carried out using a Nix Pro Color Sensor; a hand held digital device with its own calibrated light source and which is operated using a smart phone application. This made it possible to take digital readings of extant samples in controlled environments where it was not possible to bring the samples to desk-top spectrophotometers. The author's Nix sensor has been checked against published standard colours as well as spot checked against Sovereign Hobbies Colourcoats factory's desk mounted spectrophotometer.

The authors trust that the methods, discussion and references made herein will be found to be a robust argument by the reader, and that the reader will have a clearer understanding of the applicable timescales and relative appearances of these shades.

The author would like to extend thanks to the staff of The National Archives at Kew in London, along with Heather Johnson, Curator (Archives) of the National Museum of the Royal Navy, Portsmouth, and also a special thanks to Richard Dennis, Sean Carroll, Michael Brown and Lindsay Johnston who provided a wealth of documentation directly relevant to this paper. This research would not have been possible without the accommodation and willingness of all these sources of primary source references.

Origins

In 1942 the Royal Navy had a defined but wide set of camouflage colours standardised for use. These were the standard camouflage colours in addition to the familiar Admiralty Patterns 507A Dark Grey, Home Fleet shade, 507C Light Grey (or Mediterranean Grey, or Foreign Stations Grey) and 537 White. These were used either all over in the case of the 507s or as part of a disruptive pattern scheme. The then-current state of affairs was that there were several instances of different paint shades of the same reflected tone, an evolving understanding that most of the effectiveness of camouflage on ships was attributable to tone, not colour, and a general lack of understanding amongst the personnel within the Royal Navy about what tone actually was as far as colour science was concerned. Thus, in short, there were several paint colours providing duplicates of tone – the only quality in a shade which really seemed to matter – and a lack of translation between theory of concealment and practical application of it using the available paints. The Admiralty sought to simplify the nomenclature and rationalise the colour palette to remove duplicate tones.

A brief introduction to tone

Light Reflectance Value is the formal measure of the quality known as tone, brightness, or reflectance factor. It is a measure of the total quantity of visible light reflected by the surface, or in layman's terms, how bright or dark it appears. A low LRV gives a dark appearance and a high LRV gives a light and bright appearance. The following two blocks have the same saturation of red and blue, but on the left we have a low LRV and on the right a high LRV:



Saturation of colour is a measure of intensity of particular colours of visible light. Pure white and pure black are completely *unsaturated*, whereas a brilliant colour is highly saturated. The following two blocks have the same lightness, but on the left we have an unsaturated colour and on the right a highly saturated colour, but both are blues with no red or yellow content:



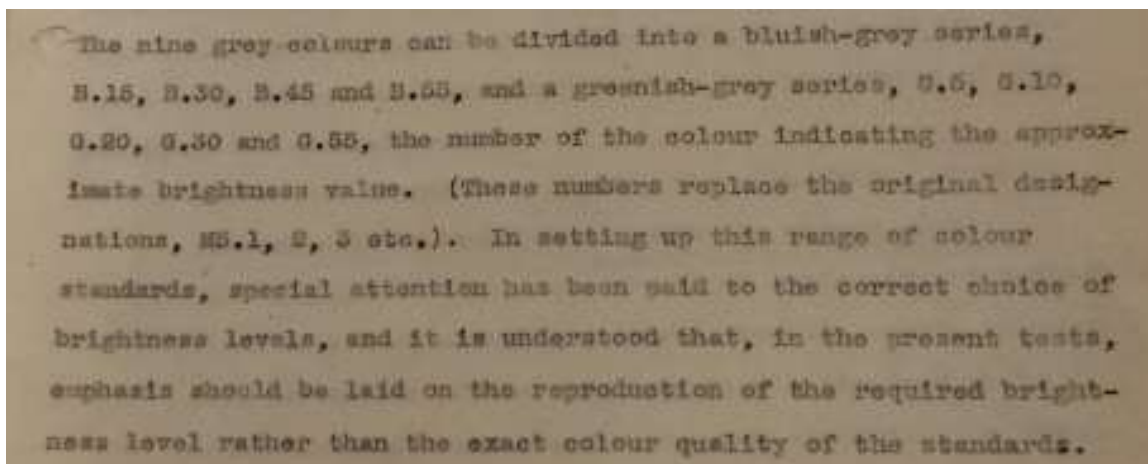
First known appearance of B & G series terminology

The nomenclature of the standard camouflage colours apparently had basis when first designated, but that knowledge has been lost to time and perhaps was never particularly obvious to the Royal Navy at large because in the latter half of 1942 the Admiralty set about a rationalisation of the paints and a new nomenclature was devised to make the relevant attributes of the colours obvious. The first known reference to this new nomenclature is recorded on a report numbered AD.29 drafted by the Paint Research Station, Waldegrave Road in Teddington, London on 15th October 1942. This document was a technical report detailing the measured colour values of three separate sets of colour samples provided by the Admiralty for evaluation. The first two sets of samples were manufactured by two civilian paint companies already providing ready-mixed camouflage paints to the Royal Navy. The third set was supplied by Portsmouth Dockyard who mixed paints in-house.

Whilst much of the document relates to the methodology used to measure the samples using what was at the time state-of-the-art scientific equipment, the report does give some important insight as well as useable

colour space coordinates and subjective descriptions. It is essential to note however that AD.29 was definitely not dealing with the final colour palette; whilst some rationalisation of colours had already taken place by the time samples were sent for evaluation (e.g. M.S.2. was not provided, as it was so similar to the well-established Admiralty Pattern 507A as to duplicate 507A's effect in camouflage) there were two colours included which were never introduced to the fleet in spring the following year.

AD.29 introduces its purpose with the following:

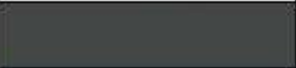
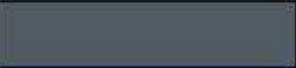

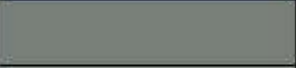
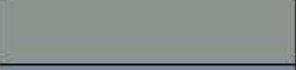
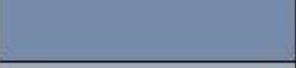
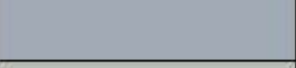
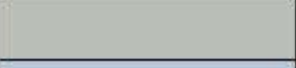
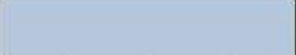


Extract from AD.29 introduction

“The nine grey colours can be divided into a bluish-grey series, B.15, B.30, B.45 and B.55, and a greenish-grey series, G.5, G.10, G.20, G.30 and G.55, the number of the colour indicating the approximate brightness value. (The numbers replace the original designations, MS.1, 2, 3 etc.). In setting up this range of colour standards, special attention has been paid to the correct choice of brightness levels, and it is understood that, in the present tests, emphasis should be laid on the reproduction of the required brightness level rather than the exact colour quality of the standards.”

In fact, the report later contradicts itself slightly by stating that G.10 is so blue in nature that it could really be called the darkest of the B series. Also noteworthy is the nomenclature of “B.45”, a bluish grey with colour values remarkably similar to 507C. The purpose of the new nomenclature is to help fleet officers not educated in colour science to select appropriate paints via guidance in principle combined with more intuitive naming. For instance, “B.15” means “Blue with 15% Light Reflectance Value”.

Of the three sets of colour samples provided, the two civilian produced sets are relatively close to one another, whilst the Portsmouth Dockyard samples are noted as being out with reasonable tolerances in some cases. The best set of samples, with respect to compliance with the specified brightness levels (or Light Reflectance Value) was provided by the company Pinchin Johnson as oil bound water paints, an early form of emulsion whilst the Portsmouth paints were linseed oil paints which were glossy and struggled to dry even indoors over the course of a week. A render of the Pinchin Johnson samples' colour coordinates as recorded in AD.29 is provided below:

AD.29 Designation	AD.29 recorded colour values	Likely origin of samples
G5		MS1
G10		507A
B15		B5
G20		MS3
G30		MS4
B30		B6
B45		507C
G55		MS4A
B55		Western Approaches Light Blue

Render of AD.29 Table 1 Colour Coordinates

Whatever correspondence may have taken place within the Admiralty between the receipt of AD.29 from PRS and the official roll-out of the new paints is unknown. What is known is that in May 1943 the Admiralty issued two documents which officially promulgated not only the new colour palette including an explanation of the nomenclature and complete set of formulae for mixing (but paints would typically be ordered pre-mixed), but also a Confidential Book publication C.B.3098 (R) providing an update of the principles of camouflage first published in Confidential Admiralty Fleet Order 679 during 1942 to take cognisance of the new paints but also a complete new set of standardised camouflage design illustrations for destroyers and small ships.

These two documents provide the key point in time where the new paints came in to use, and their nature.

The colours officially promulgated in A.F.O. 2106 on 13th May 1943 were: G.5, G.10, B.15, G.20, B.30, G.45 and B55. It is worth again pointing out that in the seven months since AD.29 had been published, B.45 had been renamed as G.45 (perhaps because, as shall soon be demonstrated, it was in fact the same colour as Admiralty Pattern 507C which was already known as Light Grey, Mediterranean Grey or Foreign Stations Grey), and that both G.30 and G.55 had been dropped.

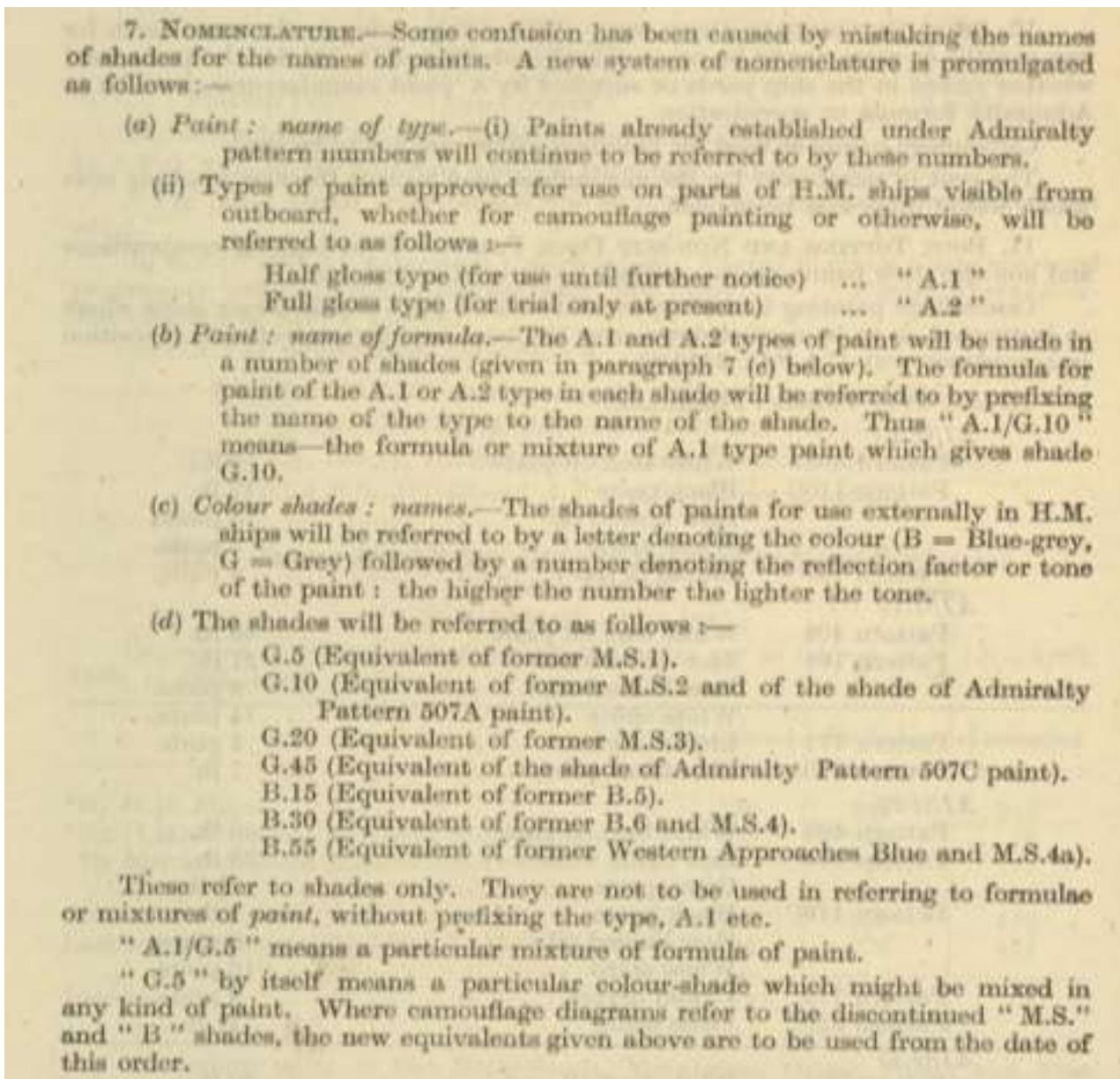
Extant evidence

All Admiralty Fleet Orders relating to the second world war are available to download from the History section of the Royal Australian Navy's website:

<http://www.navy.gov.au/media-room/publications/admiralty-fleet-orders>

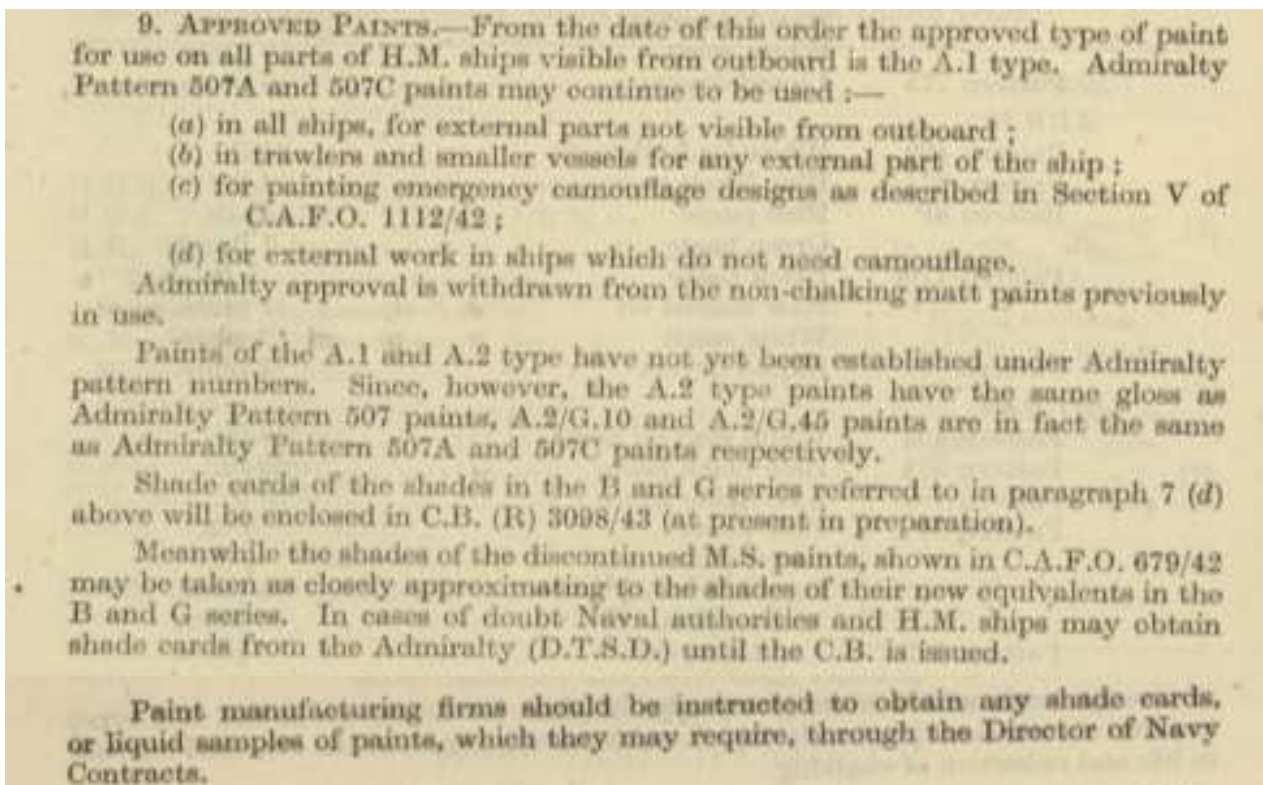
The first such document of interest is A.F.O. 2106 dated 13th May 1943 entitled "External and Camouflage Painting". Whilst lengthy as fleet orders go, it is rather comprehensive in its scope covering everything from the new paints and their formulation through to which paints to use as undercoats for camouflage.

Section 7 of this order deals with nomenclature, making the distinction between a paint and a colour (i.e. G.10 is a colour, A.1 / G.10 is a specific paint). The author notes here that the paint type A.2 was never introduced subsequently.



Section 7 of AFO2106/43

Section 9 of this order deals with approved paint types, and is mentioned because it makes reference to Confidential Admiralty Fleet Order 1112/42 which addresses emergency camouflage without the proper paints which included details of an emergency grey of equivalent tone to M.S.3., Mountbatten Pink and here, by implication, to G.20, by mixing equal parts Admiralty pattern 507A and 507C (a reproduction of C.A.F.O.1112/42 is available to download from Sovereign Hobbies Ltd's website), as well as making a particular point of stating the exact equivalence of the paints G.10 and G.45 with Admiralty patterns 507A and 507C.



Section 9 of AFO2106/43

Lastly, section 12 provided a complete list of formulae using standard oil paint supplies available to fleet and dockyard (shown overleaf):

12. A.1 TYPE PAINTS : FORMULAE.—

A1/G.5

Pattern 409	White lead oil paste	...	...	72 lb.
Pattern 110C	Black paste	...	...	12 lb.
	Raw linseed oil	...	...	16 pints.
	White spirit	...	...	3 pints.
Pattern 773	Liquid dryers	...	...	4 pints.

A1/G.10

Pattern 409	White lead oil paste	...	...	56 lb.
Pattern 104	Zinc oxide white	...	...	21 lb.
	Raw linseed oil	...	...	8 pints.
	White spirit	...	...	14 pints.
Pattern 773	Liquid dryers	...	...	3 pints.
Pattern 370A	Blue black paste	...	...	7 lb.

A1/G.20

Pattern 409	White lead oil paste	...	...	50 lb.
Pattern 104	Zinc oxide white	...	...	28 lb.
	Green paste	...	...	$\frac{1}{2}$ lb.
Pattern 110C	Black paste	...	...	1 lb.
	Raw linseed oil	...	...	8 pints.
	White spirit	...	...	16 pints.
Pattern 773	Liquid dryers	...	...	3 pints.
Pattern 52P	Paste ochre	...	...	$1\frac{1}{2}$ lb.

A1/G.45

Pattern 409	White lead oil paste	...	...	50 lb.
Pattern 371	Blue black paste	...	...	7 lb.
Pattern 104	Zinc oxide white	...	...	28 lb.
	Raw linseed oil	...	...	11 pints.
	White spirit	...	...	10 pints.
Pattern 773	Liquid dryers	...	...	3 pints.

A1/B.15

Pattern 409	White lead oil paste	...	...	61 lb.
Pattern 371	Blue black paste	...	...	14 lb.
Pattern 8P	Blue paste	...	...	$11\frac{1}{2}$ lb.
	Green paste	...	...	1 lb.
Pattern 110C	Black paste	...	...	$\frac{1}{2}$ lb.
	Raw linseed oil	...	...	11 pints.
	White spirit	...	...	10 pints.
Pattern 773	Liquid dryers	...	...	3 pints.

A1/B.30

Pattern 409	White lead oil paste	...	...	58 lb.
Pattern 371	Blue black paste	...	...	20 lb.
Pattern 104	Zinc oxide white	...	...	9 lb.
Pattern 8P	Blue paste	...	...	$\frac{1}{2}$ lb.
	Green paste	...	...	$\frac{1}{2}$ lb.
	Raw linseed oil	...	...	11 pints.
	White spirit	...	...	10 pints.
Pattern 773	Liquid dryers	...	...	3 pints.

A1/B.55

Pattern 409	White lead oil paste	...	...	40 lb.
Pattern 104	Zinc oxide white	...	...	47 lb.
Pattern 371	Blue black paste	...	...	2 lb.
	Green paste	...	...	2 oz.
	Raw linseed oil	...	...	9 pints.
	White spirit	...	...	11 pints.
Pattern 773	Liquid dryers	...	...	3 pints.

Section 12 of AFO2106/43

C.B.3098(R) was first published in May 1943 to coincide with A.F.O.2106/43, and provided guidance on the practical use of camouflage and paints. It was heavily inspired by the previous year's C.A.F.O.679/42 dealing with the same subject in largely the same format but using the 1941-1943 "MS&B" paints. One section to note however reads as follows:

"138. In Table 5 are shown specimens of the shades of paint previously referred to, with the name and per cent. reflection factor of each. The series of names used to identify the various shades (vide A.F.O.2106/43) differs from that formerly employed and published in C.A.F.O.679/42, and the corresponding name of the old series is shown in the right-hand column of the table.

The tone of some of the shades has also been slightly altered, light green (W.A.) has been omitted (see paragraph 104) as also have two tones of grey, and a blue-grey of light-medium tone (B.30) has been introduced."

The two tones of grey omitted were M.S.4 and M.S.4A. M.S.2 was also omitted but is mentioned in the explanatory column with G.10, despite 507A having been selected to serve as G.10. The introduction of B.30 could have two possible meanings. It could be a new colour, as opposed to a re-notation of B.6. The samples measured in AD.29 named "B.30" were most likely B.6 samples, but these had a reflectivity of 25%, not 30%. The wording could imply slight adjustment and thus a new shade introduced. Alternatively, the introduction of B.30 may relate back to the comparison with the 1942 equivalent document in C.A.F.O.679/42 which curiously did not feature B.6 anywhere except in a single remark about the colours of ships' pennant numbers. C.A.F.O.679/42 did however make extensive use of M.S.4, a grey of equivalent tone to B.30. Hence the introduction of B.30 in this context may simply be that the referred-to previously published standardised small-ship designs didn't use light-medium tone blue-grey (B.6), but now they would in B.30.

The National Museum of the Royal Navy, accessible via appointment at Portsmouth hold a set of samples. The author has visited and measured these samples. In addition, the author scaled down all of the above formulae and recreated a sample of each for comparison; however due to the unavailability of lead white pigment in modern times, zinc white was substituted.

	Portsmouth Samples	AFO2106/43 Formulae Reproductions
G5		
G10		
B15		
G20		
B30		
G45		
B55		

Portsmouth samples compared to AFO2106/43 formulae recreations

The A.F.O. 2106 formulae were reprinted again in A.F.O. 3113 on 15th June 1944 and again in A.F.O.3545 on 28th June 1945. A.F.O.3545/45 is useful in that it begins with a statement that it consolidates three previous A.F.O. documents and includes new changes in underscored writing. The consolidated documents are:

- A.F.O. 4224/43 which dealt with administrative matters of establishing contracts with new civilian paint manufacturers and approval of shade cards, liquid samples etc
- A.F.O. 1017/44 which dealt with substitute green pigments where Chrome Green was unavailable (making particular mention that alternative greens should lean towards blue, not yellow and that yellowish tendencies were to be avoided).
- A.F.O. 3113/44 which repeated the A.F.O.2106/43 formulae but added B.20

The addition of B.20 in A.F.O. 3113 read as per the following:

Shade cards of the shades in the B and G series referred to in paragraph 7 (d) above are enclosed in C.B.(R) 3098/43, with the exception of B. 20, which shade is obtained by mixing equal parts of paints of shades B. 30 and B. 15.

A.1/B.20

Obtained by mixing equal parts of A.1/B.15 and A.1/B.30.

Extracts of A.F.O. 3113/44

It is noted in the 1945 edition of C.B.3098(R) (45) that B20 was selected for standard Scheme A due to its suitability in approximating the appearance of the sea at long ranges, at night and at dusk and dawn in tropical climates year round or at home and the Mediterranean during summer months. Thus, the addition of B.20 to the B&G series was perhaps more due to the desirability of a 20% tone blue colour over an equivalent tone of green for the predicted duration of the war against Japan; by this time Germany's ability to threaten the Royal Navy was greatly diminished. It does not indicate that G.20 was a problematic colour in terms of compliance with the standard, although whilst the author's experience could make it tempting to hold such a theory, no evidence has been found one way or the other to explain the introduction of B20. At any rate, G.20 was still there in AFO3545 one year later as noted above. Had G.20 been a problematic colour it would likely have been withdrawn in subsequent publications.

Comparison of evidence

The National Museum of the Royal Navy, accessible via appointment at Portsmouth hold a set of samples. The author has visited and measured these samples. In addition, the author scaled down all of the above formulae and recreated a sample of each for comparison; however due to the unavailability of lead white pigment in modern times, zinc white was substituted. The results are compared with the AD.29 below.

	Portsmouth Samples	AFO2106/43 Formulae Reproductions	AD.29 recorded colour values of supplied samples in 1942
G5			
G10			
B15			
G20			
B20	Not issued	AFO3113/44 derived	No equivalent
B30			
G45			
B55			

Unaged appearances of B & G series paints compared to samples

What is immediately obvious comparing Portsmouth's samples to known colours such as G45 / 507C is how badly they have darkened and shifted towards yellow. This is a tendency very well known within the paint industry in linseed oil based paints, but paints containing chrome green pigments (named G.20, B.15, B.30 and B.55) suffer a compound effect because chrome green is made synthetically by precipitating Prussian Blue onto Chrome Yellow. Over time the chrome yellow decomposes the Prussian Blue through photochemical reaction and the results are normally a surprisingly strong shift towards yellow.

Of all of the paints however, G20 gave cause for particular scrutiny and debate between the author and co-researchers. In brief, the formula as given does not result in a 20% LRV colour. Several members of the research team tried creating it ranging from “by the book” to the formula to measuring each colour via graph paper by 2-dimensional area. The more accurate the methodology, the worse the result. The nature of the pigments contained are, however, known and thus the quadrant of the colour wheel is known. Also known is the specified light reflectance value and as such we know what G20 *should* have looked like.

In order to achieve a strong olive as per Portsmouth’s sample, or indeed countless interpretations seen in modern artwork and models, a very substantial proportion of ochre yellow pigment would have been required in the mix. The author considers the inclusion of such a disproportionately large quantity of a staining ingredient which should have been added as 1.5lbs per cwt to be questionable, and submits that the current dark olive appearance of the G20 sample is due to the compound effects of this paint having darkened due to its linseed oil base and the inclusion of chrome green but without ultramarine blue to preserve a bluish impression through the aging process like the others which contain chrome green.

Also of note was B55, which has a formula with barely sufficient staining ingredients to move the resultant colour away from its white base. Whilst again in the correct colour quadrant, the result of the reproduction was less saturated in colour intensity than the design plates published in CB.3098(R) or indeed the Western Approaches colours it replaced, whilst noting also that it additionally replaced the very light grey MS4A.

It should be born in mind that, despite the above, ready mixed continued to be purchased from a list of approved civilian companies, and that the formulae given to make paints to these colours in A.F.O.2106/43 using linseed oil may have been derived from Portsmouth or another dockyard. If the samples supplied to PRS as evaluated in AD.29 were instructive then the civilian companies providing much of the paint used in these years were likely better at it than the navy’s dockyards. There is no guarantee that the formulae printed in A.F.O.2106/43 actually resulted in exactly the same shades as the official shade cards supplied with each copy CB.3098 (R). Unfortunately all surviving samples of these official shade cards, including those held at Portsmouth are 75 years old at time of writing and display common effects of aging.

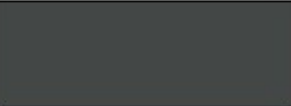
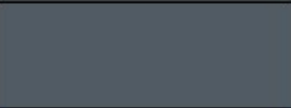
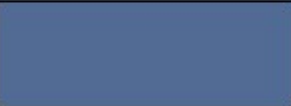


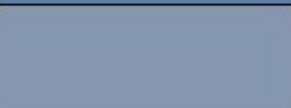
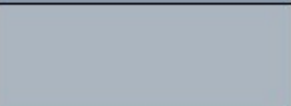

It can be seen that the Admiralty Fleet Order was the mechanism used post-1943 to introduce new paint colours, and should the reader browse some of those files available to download, it will be understood that this was the means of communicating everything from camouflage paints to instructions for granting shore-leave in foreign ports to sailors. In short, the Admiralty Fleet Order was the primary means of communicating the Admiralty’s will to the fleet.

It should be noted that by A.F.O.3545 at the end of June in 1945, and the publication of C.B.3098(R) (1945) no variations or alternative appearances have been introduced; i.e. no khaki-hue “late war” G45, nor a “late war” khaki hue B55.

Expanding upon that, there are numerous books available which have been published within the last two decades which state that the B-series in particular are olive greens. It can be seen from the pigmentation formulae given above and the period explanations of nomenclature that B was by definition blue and that white, black, ultramarine blue and a dash of chrome green cannot make an olive shade – olive requires white, black and a large quantity of yellow pigment.

Conclusions

The 1943 to 1943 B and G series paints are arguably the best documented of the Royal Navy's colours during the second world war, and the preserved records appear to be complete, if aged in the case of the sample cards. In all cases except G.20 previously discussed, the A.F.O.2106/43 formulae produced fresh oil paint samples which fitted the written descriptions of each shade, were credibly close to the documented brightness values (Light Reflectance Values) and corroborated acceptably well with the AD.29 colour coordinates in most cases.

Designation	Most likely unaged appearance of promulgated shades at stated brightness (Light Reflectance Value)	Brightness / Light Reflectance Value
G5		5%
G10		10%
B15		15%
G20		20%
B20		20%
B30		30%
G45		45%
B55		55%

Most likely original appearances

G.5 was described as a greenish grey, and on at least one occasion as black. It wasn't quite black but was close to. It is worth observing that the black pigment dominant in G.5's formula does have a green bias. Thus, a perfectly neutral black would not be achieved.

G.10 was Admiralty Pattern 507A, a dark grey with a pronounced bluish caste.

B.15 was almost certainly a re-notation of B.5 in all practical sense. Being ultramarine based, it could tend towards red and thus the formula includes a very small amount of green pigment to offset the red.

G.20 has not been possible to prove positively, however with adjustment to black content it is possible to darken the liquid sample to very closely resemble The National Archives' surviving sample of M.S.3 in ADM212/124. It does not seem credible to create a strongly saturated olive shade using the pigment ratios contained. The author carried out sensitivity cases on wet samples multiplying ochre yellow and chrome green content by up to a factor of eight compared to the white base as given in the fleet orders previously discussed, and still could not create such a strong olive as presented in other works. The most likely appearance of G.20 keeping within the realms of reason for pigment proportions is equivalent to that of M.S.3.

B.20 was sampled as per A.F.O.3113/44 by mixing equal parts of the author's wet samples of B.15 and B.30 as per A.F.O.2106/43 formula, and the appearance and brightness were, perhaps predictably, approximately the average of the colour coordinates of the two constituent paints.

B.30 was almost certainly a descendant of B.6, but if the tone was changed it was most likely lightened. Indeed the A.F.O.2016/43 formula when reproduced gave a slightly greyer appearance than the AD.29 data for same. The colour would be described as a blue-grey.

G.30 was never introduced in the fleet orders.

G.45 was Admiralty Pattern 507C, a light grey with a pronounced bluish caste.

B.55 was the lightest camouflage paint used besides white and was a light blue with a green bias. This differs from Western Approaches Light Blue, which was also known as Peter Scott Blue because B55 contains green pigment whereas Peter Scott Blue was purely a mix of ultramarine blue and white pigment.

G.55 was never introduced in the fleet orders.

References

In compiling this work, the authors have specifically referenced the following resources, and encourage the reader to review these sources for themselves:

- 1) ADM 212/124 Standardisation of Admiralty camouflage colours - (including AD.29 dated 15th October 1942) – Available at The National Archives, Kew, London
- 2) AFO 2106/43 External and Camouflage Painting (HM Ships Available to download from the Royal Australian Navy website <http://www.navy.gov.au/media-room/publications/admiralty-fleet-orders/1943>
- 3) AFO 3113/44 External and Camouflage Painting (HM Ships) – Available to download from the Royal Australian Navy website <http://www.navy.gov.au/media-room/publications/admiralty-fleet-orders/1944>
- 4) AFO 3545/45 External and Camouflage Painting of H.M. Ships and Vessels – A.1. Type Paints – Trials of Synthetic Resin Paints – Shade Cards of Camouflage Colours – Available to download from the Royal Australian Navy website <http://www.navy.gov.au/media-room/publications/admiralty-fleet-orders/1945>
- 5) C.B.3098(R) The Camouflage of Ships at Sea, May 1943 – republished by White Ensign Models using Snyder & Short paint chips (Print 2) (Prints 1 and 2 appear to have used different colours). Available with digitalised design plates from Sovereign Hobbies Ltd as of 2018.
- 6) C.B.3098(R) (1945) The Camouflage of Ships at Sea, 1945 – National Museum of the Royal Navy and Admiralty Library, Portsmouth naval base, UK. Available with digitalised design plates from Sovereign Hobbies Ltd as of 2018.

We have consulted every paint and camouflage-relevant file, AFO and CAFO we have been able to find or access in UK and Australian archives amongst which the following proved directly relevant to the B and G series paints although the following were useful references also helped shape our thinking:

- C.A.F.O.679 SEA-GOING CAMOUFLAGE DESIGNS FOR DESTROYERS AND SMALL SHIPS - 9th April 1942 – Available at The National Archives, Kew, London
- ADM 212/124 Standardisation of Admiralty camouflage colours - (including AD.29 dated 15th October 1942) – Available at The National Archives, Kew, London