British Army Green Paints

Clive Elliott lifts the lid on the thorny subject of post-war green paint used by the British Army

It is widely known that in the immediate post-war period British Army vehicles were painted in high gloss Deep Bronze Green, which later changed to a matt finish NATO Green infra-red reflecting (IRR) paint. The point at which this change took place is the subject of much debate. It is hoped that these notes, drawn from official sources, will help explain the efforts and ideas at work during what was quite a long period of change.

On 1st January 1948, the Fighting Vehicles Design Department (FVDD) laid down the painting requirements for all Service vehicles. This superseded AFV Specification 2012 dated 6th February 1945 and Specifications issued by the Directorate of Fighting Vehicles Inspection (DFVI) AFV Specification 2013 and Specification MC 286C.


MINISTRY OF SUPPLY

FIGHTING VEHICLES DESIGN DEPARTMENT

F.V. SPECIFICATION

2012

PAINTING OF FIGHTING AND MECHANICAL

TRANSPORT VEHICLES, TRACKED AND WHEELED.

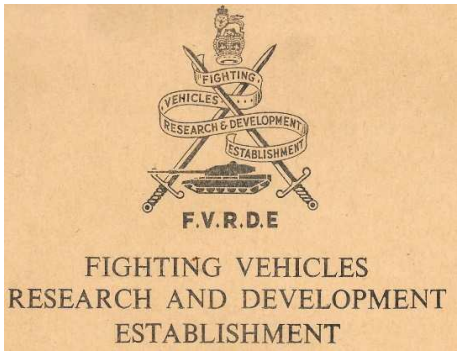
For AFVs (Armoured Fighting Vehicles) and MT (Mechanical Transport) vehicles the external bodywork was to be painted with an undercoat of Dark Battleship Grey BS Colour No. 32 (Air drying to Specification CS2390 or stoving to Specification CS2391). Followed by high gloss Deep Bronze Green BS Colour No. 24 (Air drying to Specification CS2392 or stoving to Specification CS2393 or heat resisting to Specification CS2394).

Note that these BS Colours comprise just two digits because they are based on BS 381 “Colours for ready mixed paints” drawn up in 1931 on the formation of the British Standards Institution from the British Engineering Standards Association. This standard gave 57 colours but was expanded to 93 colours in 1948 to become BS 381C this included many new colours and the addition of a prefix to give colour groups.

100-199 = Blue and turquoise
200-299 = Green
300-399 = Yellow, cream and buff
400-499 = Brown and pink
500-599 = Orange and red
600-699 = Grey
700-799 = Purple and violet

To take account of these changes an amendment was issued to Specification 2012 on 11th March 1948 so that Dark Battleship Grey BS Colour No. 32 became No. 632 and Deep Bronze Green BS Colour No. 24 became No. 224.

This was the standard colour scheme for Army vehicles other than those in the Middle East Command that required an undercoat of Deep Cream, BS Colour No. 353 with a finishing coat of Light Stone, BS Colour No. 361. The British Standard was amended in 1949 to bring the total to 97 colours. This was not just to add more colours but some names were changed and others clarified. This included the change of Dark Battleship Grey to Dark Admiralty Grey. FVDD became FVDE in March 1948 to then be incorporated into FVRDE on 1st January 1953.



Despite this Specification, by May 1952 the Inspectorate of Fighting Vehicles (IFV) had received several thousand complaints about defective painting of military vehicles. A special section of the Materials Branch was formed to investigate together with the Chemical Inspectorate (CI).

Part of the problem was that contracts called for one of three sets of requirements for painting, depending whether the vehicle was in the Combat (CT), General Service (GS), or Commercial class (CL). This resulted in three painting standards:

1. In accordance with FVDE Specification 2012.
2. Manufacturer's standard primer, with finish paint either to body builder's specification, or to the requirements of Specification 2012.
3. Paint entirely to the manufacturer's own specification.

The faults occurring included, blistering, rain spotting, lack of adhesion between coats, crazing, wrinkling, flaking, soft films, omission of one or more coats from the system, and complete breakdown of the painting system due to moisture content. The causes identified included, inadequate preparation of surfaces, poor painting techniques, inadequate painting facilities at various works, inadequate paint film thickness, use of incompatible materials, materials of doubtful quality, and a complete disregard for the importance of producing a sound painting system.

During the period 1950-53 there was a shortage of some of the raw materials for paint manufacture. Substitute materials were used and specifications relaxed. But by 1953-54 there was an epidemic of problems due to peeling and blistering of topcoats.

Attempts by IFV Materials Branch to upgrade the requirements for Specification 1012 were opposed from several quarters, including the Production Branch of IFV itself. Industry was under great pressure to fulfil re-armament demands, and there was an attitude that painting was mainly a decorative procedure rather than a method of preservation. Further specifications laid down in DEF-1044 for vehicle paints and DEF-1045 as the stoving version, these were published in 1952.

DEF-1044 1. Paint, Finishing, Vehicles, High Gloss ; 2. Paint, Finishing Vehicles (Heat-Resisting), High Gloss ; 3. Paint, Undercoat, for Paint, Finishing, Vehicles. Nov. 21, 1952. Superseding C.S. 2587C and C.S. 2590B.

DEF-1045 1. Paint, Finishing, Vehicles, High Gloss, Stoving ; 2. Paint, Finishing, Vehicles (Heat-Resisting), High Gloss, Stoving ; 3. Paint, Undercoating, Vehicles, Stoving. Nov. 21, 1952. Superseding C.S. 2589A.

IFV and CI developed tests to determine which paint systems performed well under a variety of conditions.

DEF-1053 Standard Methods of Testing Paint, Varnish, Lacquer and Related Products. Methods :

1 Preliminary Examination and Preparation of Samples for Testing. Sept. 26, 1952.
2 Preparation of Panels for Test Purposes. Sept. 26, 1952.
3 Consistency by the Flow Cup Method. Sept. 26, 1952.
4 " Soluble Lead " Content. Sept. 26, 1952.
5(a) Flash Point by means of the Abel Apparatus. Sept. 26, 1952.
5(b) Flash Point by means of the Pensky-Martens Apparatus. Sept. 26, 1952.
6 Determination of Water. Sept. 22, 1952.
7 Surface-Drying Time. Sept. 26, 1952.
8 Hard-Drying Time. Sept. 26, 1952.
9 Tack Freedom. Sept. 26, 1952. 6*d.*
10(a) Colour Comparison with Colour Standard. Sept. 26, 1952.
10(b) Colour Comparison with a Freshly Prepared Standard. Sept. 26, 1952.
11 Gloss (Specular Reflection Value). (This Method is for the Measurement of Specular Reflection Values in Excess of 50 per cent.) Sept. 26, 1952.
12 Opacity (Contrast Ratio). Sept. 26, 1952.
13 Bend Test. Sept. 26, 1952.
14 Scratch Resistance. Sept. 26, 1952.
15 Pressure Test. Sept. 26, 1952.
16 Setting Time. Sept. 26, 1952.
17(a) Resistance to Impact (Falling Weight). Sept. 26, 1952.
17(b) Resistance to Impact (Pendulum Test). Sept. 26, 1952.
18 Alkali Resistance of Plaster Primer. Sept. 26, 1952.
19 Resistance to Softening by " Petrol ". Sept. 26, 1952.
20 Resistance to " Petrol/Benzol " Mixture. Sept. 26, 1952.
21 Resistance to Mineral Oil. Sept. 26, 1952.
22 Resistance to White Spirit. Sept. 26, 1952.
23 Resistance to Salt Water. Sept. 26, 1952.
24 Resistance to Continuous Salt Spray. Sept. 26, 1952.
25 Resistance to Humidity under Condensation Conditions. Sept. 26, 1952.
26 Resistance to Accelerated Weathering. Sept. 26, 1952.
27 Resistance to Heat. Sept. 26, 1952.

DEF-1053 Standard Methods of Testing Paint, Varnish, Lacquer and Related Products. Methods :

28(*a*) Resistance to Kerosine. Nov. 25, 1953.
28(*b*) Resistance to Kerosine (for the Testing of Textured Paints only). Nov. 25, 1953.
29 Resistance to Sea-Water Immersion. Nov. 25, 1953.
30 Non-Slip Properties. Nov. 25, 1953.
31 Assessment of Sheen. May 10, 1954.
32 Development of Sheen. May 10, 1954.
33 Fastness to Light. May 10, 1954.
34 Resistance to Battery Electrolyte. May 10, 1954.
35 Fire Retardance (Indirect Heating Method). May 10, 1954.

It was to the great annoyance of the paint trade that most proprietary paints failed to comply with the new specifications, but IFV resisted all pressure to relax their requirements. In 1954 they further enhanced the specifications for DEF-1044 and DEF-1045.

DEF-1044A 1. Paint, Finishing, Vehicles, High Gloss ; 2. Paint, Finishing, Vehicles (Heat-Resisting), High Gloss ; 3. Paint, Undercoat, for Paint, Finishing, Vehicles. June 16, 1954. Superseding DEF-1044. Nov. 21, 1952.

DEF-1045A 1. Paint, Finishing, Vehicles, High Gloss, Stoving ; 2. Paint, Finishing, Vehicles (Heat-Resisting), High Gloss, Stoving ; 3. Paint, Undercoating, Vehicles, Stoving. June 16, 1954. Superseding DEF-1045. Nov. 21, 1952.

In the fiscal year 1955-56 vast amounts of paint were being sold off as surplus, in fact 38,032 gallons of paint and 14 tons of dry paint, were put up for sale. The sale price was generally about half the contract price. In addition, following the Suez Crisis 2,000 tons of paint lay surplus in the Canal Zone. Hansard records that in Parliament questions were asked as to why this paint was being discarded and why stocks of commercial paint could not be used, as in that year just over a million gallons of new paint had been ordered. The reason given was that contracts had to be placed 18 months in advance and the Army was downsizing at an unpredictable rate. The reply seemed to miss the point that paint for Service use needed to meet improving specifications, there were annual amendments to both specifications in 1955-58 and further tests defined.

DEF-1053 Standard Methods of Testing Paint, Varnish, Lacquer and Related Products. Methods :

36 Resistance to Intermittent Salt Spray. Jan. 17, 1955.
47 Fire Resistance. Sept. 13, 1955.
48 Resistance to Rubbing (Aluminium Paints). Sept. 13, 1955.

DEF-1053 Standard Methods of Testing Paint, Varnish, Lacquer and Related Products. Methods :

49 Resistance to 'Benzole Mixture' and Water. May 7, 1956.
50 Resistance to Ethanediol (Ethylene Glycol). May 7, 1956.
51 Stopping Properties (Metal Surfaces). Sept. 3, 1956.

DEF-1053 Standard Methods of Testing Paint, Varnish, Lacquer and Related Products. Methods :

46 Webbing. March 28, 1957.
52 Resistance to Methylated Spirit. Oct. 18, 1956.
53 Resistance to Petroleum Ether. Oct. 18, 1956.
54 Reflectivity of Paints for the Interior of Optical Instruments. Oct. 18, 1956.
55 Insulating Varnishes (Clear and Pigmented) Assessment of Drying Properties. March 28, 1957.
56 Resistance to Fats. Nov. 9, 1956.
58 Resistance to Rape Seed Oil. Aug. 6, 1957.

DEF–1053 Standard Methods of Testing Paint, Varnish, Lacquer and Related Products. Methods:

57 Resistance to Scrubbing. Aug. 6, 1957.
62 Determination of Oil or Oil Varnish Content Emulsion Paints. March 25, 1958.
63 Resistance to Water Shower. March 25, 1958.

For completeness, I have included the later tests, but excluding those specific to cellulose paint, electrical lacquers etc.

DEF-1053 Standard Methods of Testing Paint, Varnish, Lacquer and Related Products. Methods:
66 Resistance to Sodium Carbonate Solution. Feb., 1961.
75 Oil Absorption Value (Pigments). June, 1961.
76 Comparison of Colour in Oil (Pigments). June, 1961.
77 Comparison of Staining Power (Pigments). June, 1961.
78 Determination of Residue on Sieve (Pigments). June, 1961.

DEF–1053. Standard Methods of Testing Paint, Varnish, Lacquer and Related Products. Methods:
80. Aug. 1964. Softening Point (Ring and Ball Test).

DEF–1053 (For the Use of Government Departments and to be Quoted only in Government Specifications). Standard Methods of Testing Paint, Varnish, Lacquer and Related Products. Methods:
81 Determination of Lead in Lead-free Paints, Varnishes and Allied Products and their Containers. June 1965.
82 Determination of Fineness of Grind. June 1965.
83 Large Scale Brushing Test. June 1965.

By October 1957, what was now FVRDE Specification 2012 had also been enhanced. In addition, DEF Specification paints were used rather than the less demanding CS Specification originally specified. CS Specifications were tested as individual coats, whereas DEF Specifications required a test of the complete paint system. This combined with the newer FVRDE Specification ensured that manufacturers did not use paints in a system from different manufacturers and by 1957 an 80% reduction in complaints had been achieved. The result of all this was that IFV felt that properly applied paints, under normal use would give the vehicle protection for at least three or probably four years.

The tests in DEF-1053 were updated annually in 1957-66. In 1961 a standard was introduced for alkyd vehicle paint, amended 1963, 1966 and reprinted in 1972

DEF-1044B Paint System for Alkyd Finishing of Vehicles. Aug., 1961. (Superseding Defence Specification DEF-1044A, June 16, 1954.)

It should be mentioned that a specification was issued for cellulose nitrate paint in 1956, amended in 1959, 1963, 1965 and reprinted in 1967. Although it was listed only in Deep Bronze Green and Black, it was a paint that was only to be used for painting vehicles where an especially high standard of finish was essential. After pre-treatment of the steel, a coat of primer was followed by knifing putty of as many coats as needed, 3 coats of paint surfacer, 3 coats of finishing paint. This was followed by polishing to a high finish with compounds. By 1993 the two paints associated with this standard were no longer listed and were required were to be obtained commercially.

DEF–1145 Paint System for Cellulose Finishing of Vehicles. Sept. 7, 1956.

I have only covered the specifications for vehicle paints, there are whole sequences of specifications for other types of paints such as primers of various types for different metals and woods, paints undercoat and finishing for War Equipment, ammunition, jerricans, steel helmets, general service, canvas, instruments etc. War Equipment covered weapons and general stores, steel helmets, cooking equipment, POL equipment and returnable POL containers. War Equipment paint was matt Olive Drab, there was no vehicle paint in this colour or finish.

DEF-1110 1. Paint, War Equipment, Matt; 2. Paint, War Equipment, Matt, Heat Resisting. Oct. 12, 1954. (Superseding C.S.2399, C.S.2400A, C.S.2402)

DEF-1111 1. Paint, War Equipment, Matt, Stoving; 2. Paint, War Equipment, Matt, Heat Resisting, Stoving. Oct. 12, 1954. (Superseding C.S.2401)

The fine details of the 1948 schemes for all vehicles and equipments were amplified in EMER WORKSHOPS N 251 specifying the exact paints to be used to the latest specifications in 1959 and updated again in 1962.

Problems with Gloss Paint

The purpose of painting military vehicles was for preservation, camouflage and morale. Although gloss paint can look very smart and provide good protection from the elements, there was a growing concern in the late 1960s that tactically it was not good to have a paint that could glint in the sunshine and define all the vehicles as being British whilst our NATO partners had switched to a matt finish.

A review was carried out in 1971 to bring together all the problems with the existing paint systems and to decide how best they could be overcome. The review states *"Since World War 2 the types of paint used for painting vehicles and equipment have varied and until 1965 there was no standard policy"* and *"In 1965 a bronze green gloss paint was accepted as the standard means of protecting Army vehicles and equipment"* and quotes the Equipment Regulations Pamphlet No. 9. to indicate the current regulations. It seems to ignore the FVDD specification of 1948 and the improvements made subsequently.

Looking at Equipment Regulations 1947, Pamphlet No. 9 is on an unrelated subject, moving to the next regulations these were published in 1955 and again in 1959 and 1964. Here it gives a detailed overview as to what was required for vehicles of their various kinds, as far as colour and finish go, these seem unchanged from the 1948 specifications. Indeed MVEE Specification 525 issued in February 1971 and amended to 1977 still adhered to the 1948 specifications. The issues under consideration were:

Gloss or matt?
Monotone or disruptive pattern?
Infra-Red Reflectance?
Chemical warfare agent vulnerability?
Durability of paint?
Logistics and cost of a new paint system?

Disquiet with Gloss Paint

A growing disquiet among senior commanders about the use of gloss paint was officially voiced after Exercise 'LINK WEST' in 1967. It was felt that the shine from painted vehicles could not only identify them but highlight their outline. It was also felt that it was bad for morale as the paint scheme cut across all the efforts made by soldiers to camouflage their positions. A Royal Armoured Corps manual of the era advised that "*Shiny paint must be dulled using a mixture of dust and oil, mud or netting*". It was also felt that a disruptive paint pattern would be helpful.

Consequently, two trials were set up, one in 1968 by the Army Strategic Command and the other in 1969 by the Stores and Clothing Research and Development Establishment (SCRDE).

Project 212

This was the trial set up by the Army Strategic Command that ran from May to November in 1969. Vehicles were observed and photographed both from the ground and from helicopters during exercises in a variety of locations around the UK. In the last three months of the trial it included exercises in Denmark, Germany and the Mediterranean.

Vehicles were painted in matt Olive Drab BSC 298 and Service Brown BSC 499 both to CS 2890 specification. These paints were not specially formulated and consequently of low IR reflectance. The conclusions were that:

1. Matt paint was much better for concealment than the gloss paints in service.
2. They were just as durable (Although this was over a very short period and by now CS 2890 specification was outmoded by the DEF specifications)
3. Painting should be in a disruptive pattern.
4. The paints should have greater contrast than in the trial.
5. The disruptive patterns should be continuous over the vehicle.
6. There was no need to paint the interiors matt except for permanently open vehicles.

The report concluded that gloss paints were no longer acceptable for camouflage purposes and matt paints should be introduced with disruptive patterns.

Project 686

This was the SCRDE trial that ran from late summer 1969 to early summer 1970. The trial took place mainly in the UK but included some observations made in the Persian Gulf. The purpose was to assess the advantage of matt over gloss paints, any benefit of disruptive painting and the optimum degree of IR reflectance required.

For this trial the Quality Assurance Directorate (Materials) - QAD (Mats) provided matt paints to specification TS10038 War Equipment, matt, infra-red reflecting in four colours, Cedar Green (not BSC), Olive Drab (BSC 298), Service Brown (BSC 499) and Black. These paints must presumably have been mixed specially with varying levels of IRR pigments to determine an optimum IR reflectance level, clearly not stock paints. At that time, there was no UK or NATO standard defining what the IRR level should be.

The trial vehicles were painted a single colour on one side and disruptively on the other, so that comparisons could be made using the same location and lighting. The vehicles were observed visually and photographed at ground level and from helicopters. The conclusions were:

1. The initial use of three colours proved to be pointless, so the trials continued with just two colours.
2. For a woodland situation the best camouflage was obtained with matt Olive Drab BSC 298.
3. For a woodland environment the degree of IR reflectance needed was 35%
4. There was shown to be no proven advantage in using a disruptive pattern, although for morale reasons it was worth doing.
5. Disruptive pattern is of value in snow conditions, with 50% of the vehicle covered with “a white substance”.

Implementation

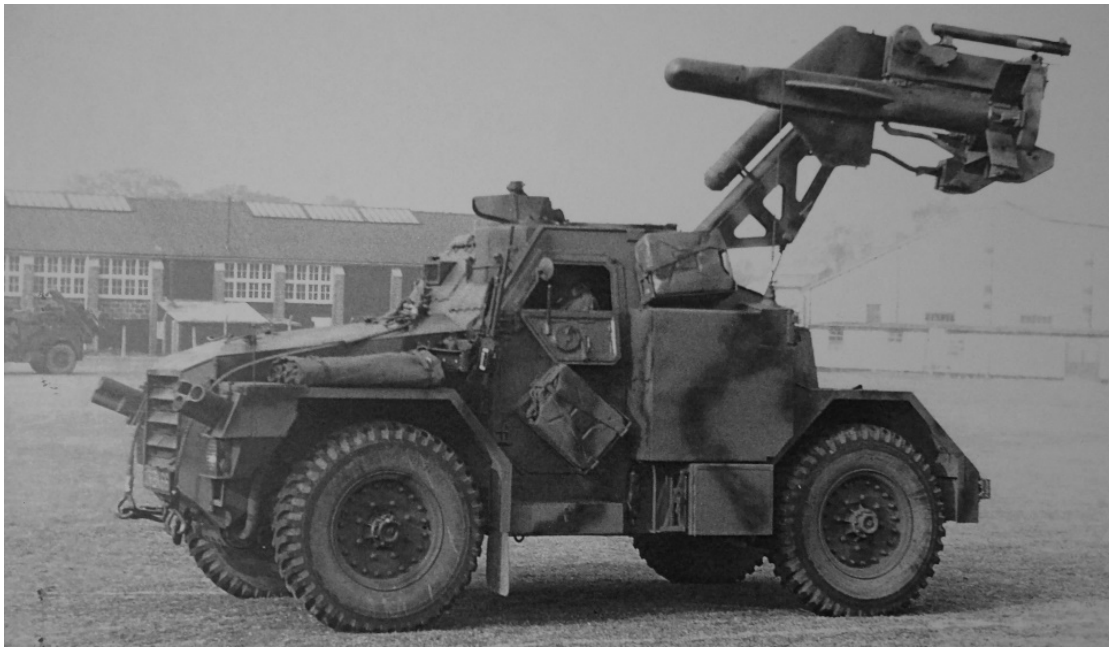
The trials clearly demonstrated that a matt paint offered superior camouflage over a gloss paint. Any advantage of a disruptive pattern could not be proved, but it was considered that it helped soldiers adopt a mindset that camouflage is all important. The Canadians in BAOR painted their equipment in a disruptive pattern and Germany was about to do the same having made a 5-year study of camouflage systems.

It was also accepted that a matt green paint with 35% IR reflectance disrupted by matt black with only 5% IR reflectance was satisfactory for the woodland conditions found in NW Europe. These figures agreed with the experimental results obtained by France and Germany and indeed in the level of IR reflectance already in use in Sweden. In Paris May 1971, the NATO Camouflage and Concealment Working Party reviewed the specifications for “a NATO Green IR reflecting paint”. The proposed UK Olive Drab paint would meet the requirements of the draft specification STANAG 2338.

But there were other issues to consider, the vulnerability to absorbing chemical warfare agents and the time to develop a suitable paint system, the cost and the logistical challenge of painting so many vehicles.

A perfect paint was some way into the future, but the operational need was urgent and there were no vehicle paints that were matt Olive Drab. So as an interim measure Paint, War Equipment, Matt, Olive Drab was used as the colour and was similar to the types of green used by other NATO nations and fulfilled the colour criteria for STANNAG 2338, although it contained no special IRR pigments.

By 1970, as an interim measure, this ordinary type of paint was used to repaint vehicles and equipment in 1 (BR) Corps and 3 Division. Probably slightly earlier, elite units like the Parachute Squadron RAC had their Hornets in matt paint liberally sprayed with disruptive black and devoid of any unit or formation badges. The Hornets went out of service in 1969, so these in-service pictures below can be no later than that date.



(Parachute Sqn RAC OCA)

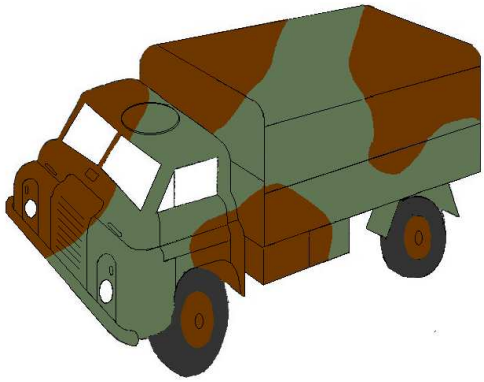
(Parachute Sqn RAC OCA)

Other Paint Schemes

The Working Party Review of paint schemes was circulated in October 1971. In the following month, the Royal Armoured Corps published instructions for painting vehicles for camouflage purposes. Three different schemes were described, it is not clear whether this was the RAC just wanting to get on with something other than plain green or whether it was part of an extended trial as it was published under the direction of the Chief of the General Staff.

Contrasting colours in large shades

The purpose was to disguise the vehicle's silhouette by using a few large shades of contrasting colours, the example given was for leaf green and medium brown.

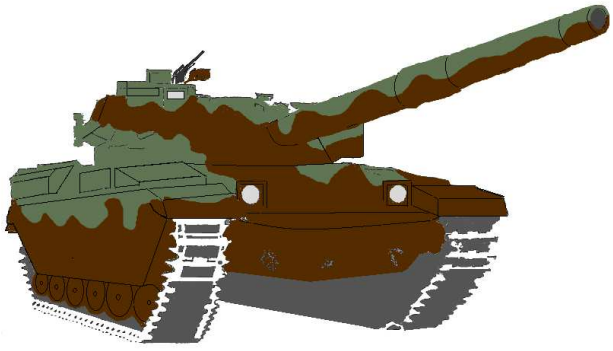


Contrasting colours in three height shades

Upper surfaces of vehicles show up as a lighter colour than the lower surfaces because the lower areas are in more shadows. This can be offset by using darker colours at the top and lighter lower down. Three or more colours may be used but no particular shades were specified other than the darker shades matching the local environment. This scheme is best suited to hot dry climates where there is strong sunlight, it would not be suitable in wet conditions where the lightest shade may be compromised with mud splashes.

Distorting and extending natural shadow areas

A very dark paint can be used to distort and extend areas of natural shadow. This is most suitable for AFVs where there are shadows under the tracks, wheels, suspension and under the sheltered areas of the turret.



Other variations

Until a firm policy on painting could be established it seemed it was up to individual units to make use of what paints that they had at hand. Variations of the green and brown disruptive pattern were seen in Northern Ireland in rather different ways. Some Humber Pigs were seen in a medium green with a light brown disruptive pattern and the Commer Water Cannons were dark green with dark brown disruption. Rather curious schemes for an urban internal security role.

The RAC instructions for painting make frequent use of Leaf Green paint, this is not a BS Colour nor does this shade appear in any stores catalogue. It looks like it is a suggestion to use any light green paint that could be obtained. Here is the 1 Tonne of the QM (Tech) AMF (L) Squadron RAC, so he would have been aware of the RAC instructions.

(Geoff Fletcher)

The most widespread scheme amongst various units was Olive Drab with disruptive matt black. The Bedford below is one of the few camouflaged vehicles circa 1970, the cab seems to be of a lighter shade than the rear body.

(Geoff Fletcher)

Below a nice line up of Bedfords at RAF Catterick in about March 1971. Note the similarity of the schemes, something that was later forbidden so that vehicles of a particular unit were not identifiable.

(Geoff Fletcher)

Especially unusual was this Commer with black that was sprayed on, reminiscent of the Hornet seen earlier.

(Geoff Fletcher)

Although the message was out that disruptive painting was the way to go, the availability of matt green paint meant that occasionally matt black was applied over what seems likely to have been gloss Deep Bronze Green. This can give a very dark appearance on this UK-based Rover of 4 (V) Bn Para in 1971.

(Geoff Fletcher)

(Geoff Fletcher)

I encountered this scheme myself when I restored my Shorland over 30 years ago. On issue to 5 Bn UDR in 1970 it was painted in gloss Deep Bronze Green with a matt black disruptive pattern. I copied the pattern exactly and much criticism I received for it, as I was firmly told by many experts that such a scheme would never have been done in service.


(Author)

NBC Threat

In November 1970, the General Staff issued an Operational Requirement about protection to NBC attack. There was little protection that paint could provide against a nuclear attack other than not to burn and both the gloss and interim matt paints were already made to a heat resisting specification, as a precaution against burning it was stated that the new paint matting agent was to be silica. Biological agents were thought to pose no immediate threat because the Soviets had not organised themselves for it as a standard form of warfare and besides it was thought that biological agents would not have any effect on paint. However, chemical warfare was something that the Soviets had comprehensively trained for.

It might seem that a gloss paint would allow for a more effective decontamination than a matt finish, but the problem with all these paints were that they were alkyd and absorbed chemical agents. The Weapons Equipment Policy Committee (WEPC) was the body that would authorise any overall change in painting policy, they had already declared that the materials used in future equipment should ideally be completely impervious to chemical and biological agents.

At the time decontamination of vehicles and equipment would only be partially effective as the absorbed agent slowly evaporates posing a vapour hazard to personnel. This would mean long periods when troops would be wearing full protective clothing, which would seriously hamper their effectiveness. The only solution was the use of a non-absorbent paint.

Polyurethane Paint

The persistence of chemical agents in polyurethane paint is very low, which can be seen from the examples below. Chemical agents were exposed to painted surfaces for 3 hours then decontaminated, over the next hour the vapour levels were recorded as a percentage of the original agent.

Paint Type	GD Agent	VX Agent	H Agent	
Polyurethane	0.2%	0.1%	Nil	Concentration non-lethal in enclosed areas
Alkyd	2.6%	2.3%	3.6%	Might be lethal in enclosed areas

The results were obtained on freshly painted surfaces, as the paint hardens with time so does its resistance to chemical agents.

Vulnerable Areas

Painted surfaces were not the only vulnerable areas. At the time, most "B" Vehicles were undersealed from new unfortunately the undersealing compounds absorb chemical agents. Although this was not considered a serious problem, polyurethane paint could not be applied to the compound. Jerricans would need to be treated with the new paint as they would usually be carried by most vehicle types and regularly exchanged for full jerricans. It was proposed that all jerricans be re-painted with the new paint by 1975. Although jerricans were already painted in Olive Drab, their refurbishment was not always considered cost effective. In 1956 the total stock of jerricans was fifteen million.

The canvas of vehicle seats absorbs chemical agents and it was expected to introduce seats of a resistant covering by 1972-73. No such plans were envisaged for vehicle canopies and they were to be discarded if contaminated. Rubber components in a vehicle will absorb chemical agents but their surface area is relatively small. The exception was tyres and in a static situation could be protected by applying a mixture of bleach and earth. Other than that normal decontamination and weathering was all that could be done.

Logistics of Repainting

It would be a tremendous task logistically and financially to re-paint the entire stock of all Army vehicles by 1976. So, the plan was to quickly get front line vehicles painted in a matt green with disruptive black. Certain administrative vehicles, staff cars and ceremonial vehicles and equipment did not need the new paint. Difficulties arose in deciding which other vehicles should be re-painted because within formations there would be a constant rotation of units bringing in their vehicles yet these would be out of place on returning to other formations not using the new paint system. Reserve Forces should not be deprioritised as they have commitments that may be called upon and require integration with Regular Forces. In consideration of all the interactions it was recommended to the WEPC that a world-wide repainting policy should be adopted.

The matt green was to be Olive Drab and as there was no vehicle paint in this finish, the existing War Equipment Olive Drab paint was to be used as an interim measure. If this could not be obtained through the usual channels then paints could be sourced locally, if this could not be achieved then the black could go on the existing gloss Deep Bronze Green. The next stage was to make available a matt Olive Drab alkyd paint that was IRR and both heat and gasoline resistant. This was in effect another interim paint, it was to be available in brushing and spraying presentations, so that it could be applied at unit level without needing any special skills or specialist equipment. At the same time a 3-part pack polyurethane paint that resisted chemical agents would become available so that a more measured painting programme could be carried out with attention to the safety aspects of the process in specialist facilities.

Financial Implications

A staged introduction of a new paint system was necessary because the final paint and its immediate forerunners were not yet fully developed, let alone available in large quantities. A staged process would also seem to have financial benefits.

Defence funding is determined by a Vote system, the budgeting for the long-term costings of the new paint system was provisioned in 1971 under Vote 5D340 for the following fiscal years on the basis below:

1972-73	1973-74	1974-75	1975-76 & so on
£600,000	£600,000	£300,000	£300,000

The sums for the two years 1972-3 and 1973-4 included the provisioning of the new paint and maintenance, with subsequent years just maintenance. Due to the review of the Defence Budget 1971 there were attempts to block the funding for the new paint system for the three years 1972-75, this would mean a major setback for implementation.

Various costings were prepared for the different stages of paint systems to be applied. The first consideration is the comparative costs for the various paints:

Gloss	Deep Bronze Green (Existing scheme)	(Alkyd)	£0.95 per gallon
Matt	Olive Drab "Interim"	(Alkyd)	£0.97 per gallon
Matt	Olive Drab IRR	(Alkyd)	£1.50 per gallon
Matt	Black IRR	(Alkyd)	£1.10 per gallon
Matt	Olive Drab IRR Chemically Resistant	(Polyurethane)	£2.75 per gallon
Matt	Black IRR Chemically Resistant	(Polyurethane)	£2.00 per gallon

Costings were provided for painting the various schemes for just 1 (BR) Corps plus 3 Division and world-wide repainting including vehicles in depots. As it was the firm belief that anything other than world-wide painting was not acceptable for a variety of reasons, I have just included the world-wide figures. There were also costings given for the different systems in one colour green or disruptive with black. Note that the disruptive pattern with IRR Black is a little cheaper than IRR Green alone. The reason is that the black paint contains less IRR pigment than the green and is therefore cheaper. This differs from the "interim" paints where there was no IRR pigment or price advantage with using black. The list below is for initial world-wide repainting with two finishing coats.

Deep Bronze Green (Existing system)	(Alkyd)	£267,000
Olive Drab "Interim"	(Alkyd)	£273,000
Olive Drab "Interim" Disruptive	(Alkyd)	£285,000
Olive Drab IRR	(Alkyd)	£422,700
Olive Drab IRR Disruptive	(Alkyd)	£396,000
Olive Drab IRR Chemically Resistant	(Polyurethane)	£775,500
Olive Drab IRR Chemically Resistant Disruptive	(Polyurethane)	£750,300

The next list is for the annual maintenance world-wide. Alkyd paints were calculated to have a two-year life, whereas polyurethane paints were calculated for a four-year life. Again, the calculations were for two finishing coats, but there was the expectation that this could be reduced to one coat for polyurethane paints.

Deep Bronze Green (Existing scheme)	(Alkyd)	£133,500
Olive Drab "Interim"	(Alkyd)	£136,800
Olive Drab "Interim" Disruptive	(Alkyd)	£142,600
Olive Drab IRR	(Alkyd)	£211,700
Olive Drab IRR Disruptive	(Alkyd)	£198,400
Olive Drab IRR Chemically Resistant	(Polyurethane)	£192,000
Olive Drab IRR Chemically Resistant Disruptive	(Polyurethane)	£187,600

Government Policy

The projection for the annual maintenance cost for the final paint system was £187,000 and fell below the original allowance of £300,000. Of course, not all vehicles would require repainting annually because the initial painting could never be completed in one year, it would be a staggered process. Further difficulties were to arise from the announcement on the 21st March 1974 that the Government had *"initiated a review of current defence commitments and capabilities against the resources that, given the economic prospects of the country, we could afford to devote to defence"*. These reductions were embodied in the Statement on the Defence Estimates 1975.

It was recognised that there was a mellowing of East-West relations so cuts could be justified, as *"the Government does not believe that the Warsaw Pact countries would contemplate outright aggression against the West in the present circumstances"*. It also had to be seen in the light of a need to cut £110 million from the 1976-77 defence budget progressively until 1983-84 with total cuts in the whole period of £4,700 million. In this atmosphere, repainting Army vehicles was not going to be a high priority.

The 1975 policy of the newly elected Conservative Government set to reverse Labour's plans for cutting the Territorial and Volunteer Reserve (TAVR), the new Government wanted closer integration of the TAVR with the Regular Army in a new District organization. Despite cuts in the order of 15,000 troops in the Regular Army, the TAVR levels were to be maintained. This had consequences for vehicles and the way that they were marked.

The Materiel Regulations for the Army 1975 were amended in August 1977 to take account of this integration. The new District based units were to display their new identity in matt white lettering 27 mm high on the front offside wing at the front and rear, bridge load plates were to change from yellow to grey. From 31 March 1978 Formation heraldic signs/badges as well as Arm/Service identifying colour signs were to be phased out as these had no place in the new "One Army" concept and besides did not fit well with the new camouflaged painting schemes being introduced.

Infra-Red Reflectance

Infra-red (IR) is that part of the electromagnetic spectrum that is below red and is invisible to the human eye. With the aid of night vision equipment, the performance of infra-red rays can be observed. The behaviour of these rays reflecting off objects such as foliage and vehicles is rather different than with visible light. For instance, a vehicle with conventional paint may reflect very little IR energy yet the chlorophyll in the surrounding leaves of foliage will reflect much more. The use of IRR paint on a vehicle is an attempt to mimic the behaviour of this foliage. In particular, the foliage of NW Europe with a suitable reflectance value of approximately 35% interspersed with black with no more than 10% reflectance an IRR paint system can give a useful degree of IR camouflage.

NATO Green IRR

The British Olive Drab that was to contain the required IRR pigment was named as "NATO Green" in BSC 381C No. 285 in 1980. In earlier reports and reviews, from time to time, there were references to developing "a NATO Green" i.e. one that complied with the NATO STANAG. Each country was free to interpret their version of "a NATO Green" that also complied with the STANAG, these were similar but not the same shade as our NATO Green BSC 381C No. 285.

NATO standard STANAG 2338 was ratified in 1971, as usually happens what is drawn up in a STANAG is largely incorporated into a British Defence Standard (Def Stan) sometime later. The designation of our new paint as "NATO Green" was marked in Def Stan 00-23 Issue 1 in October 1980.

Instructions *introducing* the use of IRR paints appeared in Materiel Regulations for the Army, Painting of Army Vehicles, Aircraft and Equipment in December 1980, these Regulations superseded the 1975 edition. The 1975 Regulations contained details of markings but despite its title, contained no information on painting, clearly indicating that the proposed new paint scheme was not yet available. The 1980 Regulations contain instructions to familiarise users with the principles in using these new paints for the first time. The description only covers the alkyd IRR paints available in brushing or spraying for NATO Green, but black was only available in brushing. The finish of the two types of green can be seen in the picture below of a load arriving in the UK docks from BAOR.

(Author)

The vehicles demonstrate the required painting technique for maximum effect at long range, consisting of large bold patterns trying to extend and distort areas of shadow. The resulting scheme should be two thirds green and one third black, this will give the right colour balance at extreme ranges when patterns are no longer obvious. Wheels should be painted in just one colour and the grey bridge load plate was to be painted in the colour of the surrounding bodywork, with the load class marked in the opposing colour e.g. black on green or green on black. Similarly, tyre pressures were no longer to be marked in white but the opposing colour.

(Author)

There was no special benefit in spraying green on the edges of hand brushed patterns as this was of marginal benefit only at very short ranges. There was no benefit in painting any equipment smaller than a ¾ Ton trailer, although it was frequently done in service and in preservation.

In 1980 no IRR paint had yet been developed that did not harm the canvas of vehicles, so these were to be left unpainted until the start of hostilities. It was not until December 1981 that specifications for IRR emulsion paints for canvas were published as TS 50111A, which eventually morphed into Def Stan 80-125. This included a few basic colours including UN White and Arctic White, neither colour had defined IRR properties but Arctic White had defined levels of UV reflectance to STANAG 2385.

Alkyd paint, without the resistance to chemical agents, was at one time regarded as a stepping stone to the world-wide use of polyurethane paint with its resistance to chemical agents. It seems curious that alkyd paints lasted so long in service, at some stage there was a change of policy, as instructions as late as October 1997 still show a parallel existence for the two paint types. But there was a policy change that all vehicles and equipment unless otherwise specified should be painted with alkyd paint and only equipments exposed to continuous immersion or contact with water merited polyurethane paint.

The Research and Technology Organization (RTO) is the scientific arm of NATO and met in 1999 to discuss a range topics including "Approaches to the Implementation of Environment Pollution Prevention Technologies at Military Bases". The paper presented by the UK demonstrated because of the Environmental Protection Act (EPA) 1990 there has been a significant pressure exerted on the paint industry by the Department of the Environment to reduce the production and release of Volatile Organic Compounds (VOC) not only the paint itself that was of concern but also the solvents and processes in preparing surfaces and particularly removal of old paint. To assist industry a set of Process Guidance (PG) notes have been issued, typical of these is "Paint Application in Vehicle Manufacturing" (PG 6/20).

Concern was expressed that STANAG 4360 – "Specification for Paints and Paint Systems, Resistant to Chemical Agents and Decontaminants, for the Protection of Land Military Equipment" lagged behind the UK who had 2 years earlier produced a low VOC standard in the form of Def Stan 80-208 for polyurethane paint that had displaced Def Stan 80-166 that was non-compliant.

Usually a STANAG is drawn up, ratified by individual members who then may decide to produce their own national standard that conforms to the basis of the STANAG, but in this case the UK showed itself to be a step ahead.

Alkyd paints (Def Stan 80-41) had been withdrawn from general use in April 2004 and in December 2004 it was decided that all vehicles painted with alkyd paint should be repainted with a new polyurethane paint to comply with the Volatile Organic Compounds Directive PG6/24. Following this ES Log Div LAND would require the equipment identification plate to be stamped **PU DS80-208** by the painting contractor to signify that the vehicle has been painted with polyurethane (PU) paint to Def Stan 80-208. It is surprising the number of defence contractors who still offer equipment to the old specifications Def Stan 80-41 and Def Stan 80-166.

Vehicle Record Cards

The description so far has covered the implementation of the new paint scheme on vehicles already in service, it would be advantageous to have new vehicles that are already painted appropriately. Vehicle record cards usually give an indication of the colour scheme of a vehicle held on census. This takes the form of a two-character code, the first character gives the basic colour and the second the finish. By noting the change in colour code a time line can be established for certain vehicle batches.

Deep Bronze Green Gloss is "72". The first character just indicates it is "Green" and the second that it is "Gloss".
Olive Drab or NATO Green in IRR is "A6". The first character indicates "Army/NATO Green" and the second is "IRR".
Olive Drab or NATO Green in IRR with disruptive pattern is "A7".
Olive Drab or NATO Green in IRR with distinctive pattern is "A8"

It is hard to ascertain what might constitute a distinctive pattern in IRR paints, but the example below may be a candidate. Geoff Fletcher's searches of about 100,000 record cards over 20 years, has failed to identify any "A8" colour codes. Although updating the colour codes on record cards was a practice that seemed to be abandoned in the 1970s.

(Author)

The first record card sighting of a change from "72" to "A6" has been noted as early 1977, suggesting the contract would have been specified in 1976. The fact that it is "A6" rather than "A7" suggests the disruptive pattern would have been applied later at unit level.

It is unclear as to the extent of the IRR paint protection that the manufacturer was required to provide at that stage. The DGFVE Specification for a 0.5 Tonne Land Rover in 1980 required matt IRR NATO Green paint to TS 10144, but part of this specification was not applied.

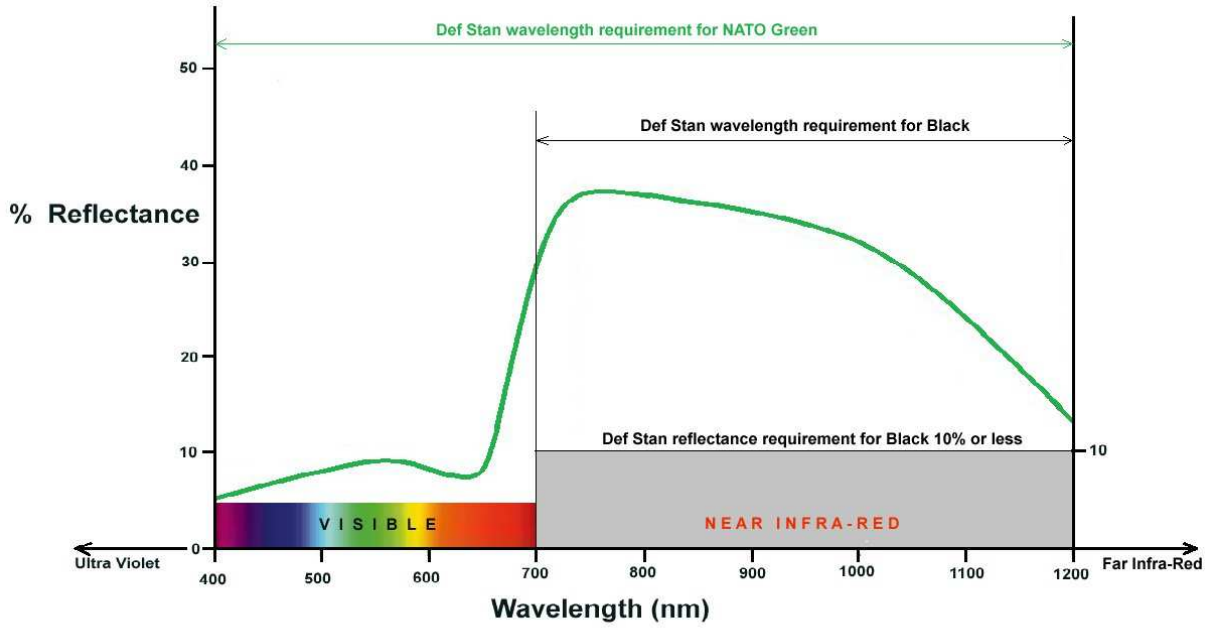
Note: The requirements of section 1 of TS 10144 do not apply in that the finishing coats only are required and that the minimum film build up is to be 15 microns. It is recognised that the full IRR requirements will not be met.

The rather thin paint layers consisted of one coat of primer, no undercoat and one finishing coat. It has already been established that a minimum of two layers of IRR paint were required to realise the full IRR performance. To what extent this minimalist painting policy applied to other vehicle types of the time is not known, but for these Land Rovers further painting was required before entering operational service.

TS 10144 was an alkyd paint specification that has interchanged with DEF 1044, which in turn was absorbed into Def Stan 80-50 that was itself deleted on 1st December 1998.

Defence Standard 00-23

Def Stan 00-23 was first issued on 17th October 1980, from the specifications quoted I have constructed a chart to illustrate the typical performance of the new NATO Green IRR paint based on the information in the Def Stan. Note that this is about the IRR performance, the specifications for the paints themselves were in series Def Stan 80. Def Stan 00-23 ran to four issues gradually including extra colours, but was declared obsolescent on 7th October 2016.



Typical Reflectance Plot for NATO Green

IRR Paint Abuse

I have witnessed many in-service vehicles at displays being smartened up by wiping down external surfaces with a cloth soaked in preservative oil. Likewise, many of us with vehicles in preservation have at times used something like WD-40 to give a more impressive display that anyone is entitled to do with their vehicle. But in-service it is rather different, it is likely that PX-24 preservative oil was used, this not only effects the IR reflectance (as it does visually) but it also reduces the chance of a subsequent paint coverings having an adequate adherence.

Just as soldiers like to see their vehicles looking smart, so do commanding officers. This has sometimes led to a feeling of unit solidarity by painting all vehicles in the same disruptive scheme, something that was specifically forbidden in the painting regulations. But commanding officers can't see everything and I have been told of instances where tall vehicles had no painting done to the roofs as they were out sight. Also forbidden was the picking out of details on the vehicle, such as maker's name, in white or a similar bright colour.

IR Absorptive Paint

Much has been made of the benefits of IRR paint but there may be circumstances in a peace keeping role where appearing to avoid detection could be wrongly interpreted by coalition partners. In 1995 during Operation Resolute, to reduce the chance of fratricide, coalition vehicles were marked "IFOR" in white "IRR absorbent" paint. But the NSN of the paint quoted relates to a standard matt white alkyd paint that would normally have minimal IR reflectance anyway.

Actual Paints

The contrast between Deep Bronze Green and Olive Drab or NATO Green is obvious. But it is not always easy to differentiate between the two matt greens, especially from old photographs of vehicles in isolation. Below is a test panel that I digitally photographed in daylight some years ago, NATO Green has a grey tinge that gets accentuated the longer the paint is exposed to sunlight.

IRR NATO Green has a 12-month shelf life, once applied it was meant to be repainted every 2 years. That is why when acquiring an ex-MOD vehicle there will often be many layers of paint, I once had a vehicle with seven layers of IRR paint that took a long time to remove. Nowadays the removal of old paintwork is influenced by environmental issues that have been building up over the last few decades. Removing layers of paint in service was rarely done, not just for the sake of the environment but it was expensive in terms of materials and labour, apart from often the lack of proper facilities. It should be remembered that the IRR effect is not just dependant on the final coat but on the layers beneath. That is why patch painting due to chipping requires two layers of IRR paint, in addition to any primer and undercoat if bare metal is exposed. For those who require a definitive assessment of IR reflectance on a painted surface, an IR reflectometer with appropriate probe could be used like this one that was ex-BAE Systems.

I now regret removing all those layers of paint and realise my vehicle would have looked far more authentic had I just painted over the old paintwork rather than try to give perhaps an unrealistically smart appearance that many of us strive for. The vehicle in question is the Carawagon, that arrived on the back of the Bedford shown earlier. It would have looked more authentic if I had left it alone!

Radar Absorptive Coating

One of the urban myths about IRR paints is the story of people claiming to have painted their vehicle in IRR paint and being able to drive through radar speed traps undetected. This makes no sense, apart from the fact that the paint is designed to *increase* IR *reflectance*, it has no bearing on the reflectance of radar signals, which is due to the metal of the vehicle. To minimise radar detection, you need to reduce the reflectance.

With the increase in battlefield radar surveillance a series of studies were conducted from January 1966 to October 1969 to assess if any covering could be applied to various types of vehicle to mask their presence by absorbing radar energy and dissipating it as heat. The early trials were carried out using Q and X band radar on an Austin K9, some success was achieved with two forms of protection, a foam fixed to the vehicle and a form of nylon fabric with overlapping slots to form a netting that was temporary, both materials were impregnated with “poly-vinylidene acetylene black dispersion”.

The later trials were carried out on two Centurion tanks and a FV432 APC. A thicker and fire retardant foam was used and a commercially available dispersion of carbon black in water was used as the radar absorber for the foam and the nylon netting. The results were encouraging for both materials, although the foam was difficult to apply in areas of movement (wheels, gun turrets) whereas the nylon fabric could be applied like a camouflage net to any vehicle. More work was needed as regards IRR properties and chemical agent protection, although the netting could be discarded if it became contaminated. None of these procedures would make a vehicle invisible to radar, but they would provide some protection by making it less discernible.

Multi-Colour Paint Patterns

It was mentioned earlier that the SCRDE trials in 1969-70 concluded that a third colour served no purpose. However, most NATO partners have adopted a three-colour system consisting of green, brown and black, known as Standard Camouflage Paint Pattern (SCAPP). Unlike the UK policy of not permitting camouflaged vehicles to have an identical paint pattern, with SCAPP all vehicles of a particular type were required to have an identical paint scheme that was specified in diagrams.

(Author)

(Geoff Fletcher)

The UK was considering whether to adopt this scheme, so field trials were conducted by the Armoured Trials & Development Unit (ATDU) during August and September 1989. Two vehicles were selected to be painted in SCAPP, a Challenger MBT and a Fox CVR(W). As there were no specific patterns for indigenous UK vehicles, the scheme had to be based on diagrams for similar sorts of vehicle, these were provided by the Bundesamt für Wehrtechnik und Beschaffung (BWB).

With two people working on each vehicle it took 8 hours to mark out the patterns to +/- 50 mm on each vehicle. Painting then took another 5 hours per vehicle. Problems arose with trying to spray the paint accurately and such areas had sheen compared with the hand painted areas. It was suggested templates would speed up the marking out process, especially as peeling occurred over the areas where chalk had been used to mark out the patterns.

The two test vehicles, and for comparison similar vehicles in UK camouflage, were viewed at various distances in different tactical situations at Wool Heath, Bovington. The viewing was by observers and photographically including thermal imagers and image intensifiers. SCAPP proved better in open ground for a static vehicle otherwise there was only a marginal benefit from SCAPP or none.

Over the next seven months the paintwork was inspected monthly revealing some peeling, chipping and fading. There was concern that this would be considerably more if the 10-year repainting cycle of other countries was adopted. SCAPP was not adopted, this was a time when even the original aspirations of repainting programme had still not been achieved. Nations that had adopted the scheme based their colours on a standard that emerged as NATO AEP-31 in 1994.

Acknowledgement
I am grateful to Geoff Fletcher for supplying many of the photographs covering this period of change and for sharing his experiences with record card research and the many conversations we have had over the years on this intriguing era of developments.

Appendix
Specifications & Standards
The meaning of CS is probably Chemical Specification as these specifications were laid down by the Director of Chemical Inspection (CI). This was a branch of the War Office Inspection Organization under the control of the Assistant Master-General of the Ordnance (Inspection) (AMGO (I)). The other elements comprised the Inspectorate of Armaments (I Arm), the Inspectorate of Fighting Vehicles and Mechanical Equipment (IFVME) and the Regional Organization.

This should not be confused with CS Specifications issued by the Air Ministry. These Air Ministry specifications first appeared in 1936 and relate to Civil Specifications. Air Ministry specifications also included DTD Specifications, the first appeared in the early 1920s. The Air Ministry Department of Technical Development produced standards in the DTD series to cover aeronautical requirements not already covered by an existing British Standard. DTD Specifications came to include technical specifications other than aeronautical engineering, this was particularly so after 1940 on the formation of the Ministry of Supply that absorbed many new or existing DTD Specifications.

In the July 1951 Defence Specifications for the Use of Government Departments were issued starting the series with DEF/1, similarly in January 1953 Defence Lists were issued starting the series with DL/1. Then in May 1956 came Defence Codes of Practice that were issued starting the series with DEF-CP-1. Other specifications were issued by the Ministry of Supply until it was abolished in 1959.

Defence Standards in their present form came about because of the policy on quality assurance set out in the 1975 Defence White Paper. Prior to that standards had existed in various forms principally as handbooks, specifications and guides. These later embraced aerospace requirements and after February 1967 were issued by the MOD (Aviation Supply). All DTD specifications were declared obsolescent from 1st April 1999 as they had either lapsed or had been absorbed and updated as Defence Standards. The Ministry of Aviation (MoA) produced their own specifications and it should be remembered that it was a different organisation to the Air Ministry. The MoA was responsible not just for military aviation research and development but also guided weapons, radar, radio and electronics. Running parallel to these were Defence Specifications and Defence Guides issued by the Joint Equipment Standardization Committee and authorised by the Joint War Production Committee (Ministry of Defence).

The authority later changed to the Defence Administration Committee, Ministry of Defence and in 1969 the responsibility for issuing these specifications passed to the Defence Materiel Standardization Committee and later to the Defence Engineering & Equipment Standardization Committee. Soon after the 1975 Defence White Paper the first Defence Standard appeared in 1976. Def Stans as they became known often embodied large elements of the NATO Standards known as STANAGs. Nowadays the issuing authority is the UK Defence Standardization, which is part of the Director Technical Organization within Defence Equipment and Support (DE&S).

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