Chapter 2-2

PREVENTION IN PRODUCTION

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PERMANENT COATINGS

Introduction

1 The permanent coatings described in this chapter are intended to remain intact throughout a component's lifetime, as distinct from renewable supplementary coatings which include paints. A permanent protective metallic coating must have a greater resistance to corrosion than that of the metal it protects. Coatings are of three general classes:

1.1 Metallic coatings which protect by preventing access of the corrodent to the underlying metal (excluders) and also protect sacrificially (galvanically) at pores, damaged areas and cut edges, for example, cladding on aluminium alloys, cadmium on steel.

1.2 Metallic coatings which protect by exclusion but do not protect sacrificially and may indeed accelerate corrosion once the underlying metal is exposed, for example, nickel and chromium on steel. These coatings are chosen primarily for reasons other than protection.

1.3 Surface conversion coatings which provide a reservoir of corrosion inhibitor at the metal surface and also act as good bases for paint.

2 Def Stan 00-970, Chapter 801 (revised) requires that almost all metal parts are painted with the exception of bushes, lubricated parts and internal pipe surfaces.

3 AP 119A-0203-1 'Electroplating and Corrosion Resisting Processes' gives details of the processes by which permanent coatings are deposited or formed. The DTD and DEF specifications cited under 'Surface conversion coatings' should also be consulted.

Cladding

4 Pure aluminium has better corrosion resistance than the stronger structural aluminium alloys and gives sacrificial protection to them. A thin layer of nearly pure aluminium, rolled on to both sides of alloy core, provides a three ply laminate sheet combining high strength with good resistance. The cut edges of the sheet should be protected by the normal aircraft finish, or by jointing compound, squeezed out during wet assembly. At exposed edges and thin spots the cladding dissolves anodically before the alloy core. The core will corrode once appreciably exposed. On each side of the sheet, cladding is 5% of the total thickness. Cladding is normally supplemented by paint.

Metal coatings applied by electroplating

5 Coatings applied primarily for protection (for example, cadmium or zinc on steel) have resistance superior to that of the underlying metal and also protect, sacrificially, exposed metal at small breaks in the coating. When the coating corrodes away, the base metal is attacked. On stainless steel, Monel or copper base alloys, cadmium is extensively employed to prevent galvanic attack where these contact other metals such as aluminium or magnesium. Cadmium coatings on steel fasteners protect the steel from rusting and simultaneously prevent galvanic corrosion of materials anodic to steel.

6 Electroplated cadmium and zinc are normally less than 25 microns (0.001 in) thick and may be as thin as 5 microns (0.0002 in) on small threaded parts. Cadmium is more effective than zinc in tropical and marine environments and is nearly always chosen for aircraft parts; zinc is more effective against an industrial environment.

7 The second class of metallic coating (non-sacrificial) is not chosen primarily for reasons of protection since corrosion is accelerated once the underlying metal is exposed. Hard chromium plate up to 250 microns (0.01 in) thick is used to improve wear resistance on sliding parts, silver for anti-fretting, and silver or gold (sometimes very thin) for electrical conductivity in wave guides and at contacts. Protection, being by exclusion alone, is proportional to thickness.

8 In decorative plating, nickel under bright chromium provides a barrier against moisture that penetrates the thin chromium; if the plating conditions are insufficiently controlled, internal stresses lead to cracking or exfoliation of the nickel.

Metal coatings applied by vacuum deposition

9 Certain metals may be applied by ion vapour deposition for specialised application. A typical example is the deposition of cadmium on very strong steels. Advantages are that the process involves no generation of hydrogen such as occurs with normal electrodeposition, and the associated hydrogen embrittlement of the steel is precluded. Aluminium is also ion vapour deposited on a limited scale. These processes are highly specialised and require sophisticated equipment: they will not become an in-service technique of application, although coatings so deposited may well be encountered. Once deposited, the coating is similar to an electrodeposited coating and should receive the same type of additional paint protection.

Electroless plating

10 Electroless deposition of nickel by chemical means, is now commercially available. Chemical plating does not depend on electric current of galvanically dissimilar metals. Non-conducting surfaces can be sensitized and

plated. The reaction proceeds catalytically. Metal is deposited spontaneously on the surface of a catalytic substrate immersed in an aqueous plating solution containing the metal ion and a reducing agent together with a compound (frequently the salt of an organic acid) which acts as a buffer and a complexing agent for the metallic ion.

11 An alloy of nickel containing 5-10% phosphorus or 2-7% boron, gives adherent, smooth, semi-bright deposits with low internal stress, and less magnetic than electrodeposited nickel. Deposits of uniform thickness can be made on articles of complex shape; hardness is about 500 VPN, increased to perhaps 1000 VPN by suitable heat treatment. A layer 25 microns thick, baked to remove absorbed hydrogen, affords good protection against stress corrosion cracking of precipitation-hardenable stainless steel. Heat treated deposits are preferred on aircraft parts. The process is covered by Def Stan 03-5.

Surface conversion coatings

12 Surface conversion coatings are produced by chemical action with or without electrical assistance. The treatment changes the immediate surface layer of metal into a film of metallic oxide or compound which has better corrosion resistance than the natural oxide film. It also provides an effective base or key for supplementary protection such as paint finishes. Treatments widely used in aircraft are:

12.1 Anodising of aluminium alloys. An electrolytic process which thickens the natural oxide film on aluminium; the film formed is hard and chemically inert. The electrolytes employed are commonly chromic, sulphuric and oxalic acids. The process specification is DEF 151.

12.2 Chromate filming treatments on aluminium alloys. Films are produced by short immersion in strongly acid chromate solutions. They are golden yellow in colour, contain soluble chromate, and are good bases for paint. The films are very thin. Refer to Def Stan 03-18.

12.3 The chromate treatment of magnesium alloys analogous to the chromate filming of aluminium. The films, brown to black in colour, are produced by fairly prolonged immersion in mildly acid chromate solutions. Of thickness about 5 microns (0.0002 in) they contain soluble chromate, give some protection alone but are normally used as bases for sealing resins and paints (DTD 911).

12.4 Chromate passivation of cadmium and zinc, analogous to the chromate filming of aluminium alloys. The film is produced by short immersion in an acid chromate solution. The film is dull gold in colour and very thin. It gives a fair degree of protection to the zinc or cadmium and is a good base for paint (DEF 130).

13 Phosphate treatment of steel, widely used on ground equipment, is seldom used on aircraft where more effective and expensive electroplating with cadmium is normal. Phosphating is by relatively lengthy immersion in a solution of the acid phosphates of iron, zinc or manganese. The film is fine, crystalline, grey-black in colour and relatively thick. It gives little protection but is an excellent absorbent base for oil or paint and prevents creepage of rust under the paint. Phosphate treatments are all proprietary (for example, Parkerizing, Bonderizing) and must comply with Def Stan 03-11.

14 Phosphating should not be applied to nitrided or machine finished steel, and steel parts containing aluminium, magnesium or zinc are subject to pitting in the bath. Some restrictions apply also to heat treated stainless and high strength steels.

Sprayed metal coatings

15 Although most metal coatings can be applied by spraying, only the spraying of steel with aluminium (or to a lesser extent with zinc) is used appreciably on aircraft. Aluminium spraying gives an adherent, somewhat absorbent film about 100 to 150 microns (0.004 to 0.006 in) thick which affords very high protection especially when supplemented by paint. The steel must first be grit-blasted to provide a rough surface. The thickness and relative roughness make the coating unsuitable for close tolerance parts.

Surface treatment of stainless steels

16 Precipitation-hardenable stainless steels are seldom coated. Resistance to stress corrosion can be improved by electroplating or electroless plating. Wear resistance is improved by hard-surfacing or nitriding, and fatigue strength by peening or nitriding. Protective coating before heat treatment inhibits carbonizing, decarbonizing and scaling. Immersion in concentrated nitric acid improves the protection given by the natural oxide film.

SUPPLEMENTARY PROTECTION

Introduction

17 Supplementary protectives include temporary protectives which are easily removed (with or without lubricating properties) and semi-permanent materials including jointing compounds, most paints and some long term protectives such as PX-32. These afford good protection for protracted periods under favourable conditions but ordinarily require renewal during the life of an aircraft. Many semi-permanent protectives can be difficult to remove.

18 Supplementary protectives are usually applied to surfaces already possessing an anti-corrosive layer either characteristic of the metal itself, like the oxide film on stainless steel, or provided by cladding, plating or other treatment. The surface must be clean, dry and free from corrosion before the protective is applied; even if the protective is described as 'water displacing' the surface should be reasonably dry.

Wet assembly

19 All static joints should be wet assembled using a sealing or jointing compound as directed, except in the following cases:

19.1 Joints incorporating a rubber seal.

19.2 Joints made with an adhesive.

19.3 Spot welded joints.

19.4 Screwed unions in fuel, oil, pneumatic and hydraulic systems.

19.5 Joints with oil grooves. Sealing or jointing compounds are not to be used on close tolerance parts which have oil grooves or holes where assembly compounds may interfere with the free flow of lubricant to the bearing surfaces. Such parts must be assembled after the application, to the static mating surfaces, of the lubricant normally used in service.

Jointing compounds

20 It is important to use the correct type of sealing or jointing compound when joints are made either with rivets or detachable fasteners. The ease with which a panel can be removed depends largely on the non-setting and anti-corrosive properties of the compound applied on the mating faces and screws; whilst the compound must withstand any temperature in service or in

stoving.

21 Jointing compounds are used for protection at joints where they act by excluding moisture and dirt and by providing a reservoir of slightly soluble chromate. Sealants are applied to joints to prevent the escape of fluids, perhaps of fuel in a fuel system. Sealants also exclude moisture and act as good jointing compounds.

22 A wide range of sealing and jointing compounds, cements and adhesives are available, some in large containers for general use, others in small tubes for specified locations on certain aircraft. Most of these exclude air and moisture and therefore have corrosion-resisting properties. But their purpose is not always primarily to resist corrosion and they are of unequal value. Some provide protection for an indefinite period under favourable conditions.

23 Jointing compounds are designed to remain soft within a joint thus permitting flexure, yet harden sufficiently to take paint on exposed edges. When joints are broken, all hardened remains of the jointing compound should be removed and fresh compound applied prior to assembly. Commonly used jointing compounds include:

23.1 Pigmented varnish jointing compound, DTD 369A.

23.2 Jointing compound, JC5A, DTD 900/4488.

23.3 Celloseel, DTD 900/4301 and Celloseel QH, DTD 900/4549.

24 Sealants in common use include PR 1301, DTD 900/4523 and PR 1431 Type 1, DTD 900/4611. Both are polysulphide sealants and are supplied in two part kits, base and accelerator. These kits must be completely mixed as supplied. Partial mixes must not be attempted.

▶ 25 Detailed information on sealants will be found in AP119A-0504-1, General Adhesives and Glazing and Sealing Compounds, Glazing and Sealing of Aircraft Components. Only sealants and jointing compounds specified in the relevant Aircraft Publication or repair scheme are to be used. ◀

Paints

26 Aircraft paints, including varnishes, lacquers, enamels and dopes for fabrics, cover a wide range of materials, organic and inorganic. Their primary purpose is to protect materials from deterioration, but they serve also to improve appearance, camouflage, identify, reduce glare, or control heat absorption and radiation. New paints and treatments are constantly being tested. Some paints must be mixed with thinners; some require curing agents; others are supplied ready for application by brush, spray or roller. Very few are suitable for direct application to untreated surfaces; pretreatment and priming are almost invariably needed before the finish can be applied.

27 Pigmented synthetic resin (psr) primer gives corrosion protection superior to that of an etch primer, but has inferior adhesion. Epoxy primer gives better corrosion protection than either psr or etch primer, but requires a treated surface. Etch primer on the contrary should not be applied over Alocrom 1200 because its adhesion to the treated surface is poor. The scheme DTD 5555A, in which an epoxy finish is applied over an epoxy primer, with or without intermediate filler, affords excellent corrosion protection. So does the epoxy scheme DTD 5567A and the polyurethane on an epoxy primer, DTD 5580A. For magnesium materials the primers must contain a chromate pigment

and be free from compounds of mercury and lead (in addition to conforming with the appropriate paint scheme specification) in order to conform with DTD 911C.

28 No paint is completely impervious to water. Aircraft paints often contain inhibitors such as calcium chromate or strontium chromate which, dissolving in water slowly, reduce corrosive attack on metals.

29 Some paints have special qualities of resistance, for example to heat or certain acids or alkalis, hydraulic fluids, or ester lubricants (synthetic oils). These paints are intended usually either for specific aircraft or particular locations on aircraft equipment. The nomenclature is often a guide to the purpose for which the paint is intended. 'Anti-sulphuric paint' (33A/ various) is for protecting surfaces near lead acid batteries or subject to sulphuric acid spillage. Similarly, erosion resistant coating (ERC) may be used on leading edges of mainplanes, tailplanes and pylons and in locations where the normal paint finish is rapidly eroded.

30 At joints between dissimilar metals, it is important to paint carefully the cathodic metal or both metals, since breaks in the anode coat will cause intensified local attack if a galvanic cell is set up under damp conditions. Direct contact between dissimilar metals is usually precluded by jointing compound or other jointing material.

Temporary protectives

31 The use of temporary protectives in production should be restricted to those areas which will be inaccessible, or to which access will be difficult, after assembly. They should not be regarded as substitutes for paint finishes, the object is to provide supplementary protection to an existing sound paint scheme. Extensive use of these protectives should be made on unpainted components prior to final assembly and painting since much corrosion begins in the period between component manufacture and final assembly. Temporary protectives used in this manner should be removed completely prior to the application of paint, jointing or sealing compounds. Details of various protectives will be found in Chapter 2-4.

32 These preservatives, in general, do not dry to a hard non-tacky film like a paint, and they are not intended to be used instead of paint. The object is protection supplementary to that provided by the initial film of paint. They are valuable in closed sections of areas difficult of access, on complex shapes and where there are dissimilar metal. They are discussed further in Chapter 2-3.

Powder coatings

33 Specalized powder coatings are now being introduced to resist corrosion and wear, for example, nylon on splines to minimize fretting corrosion. These require specialist facilities for their application; the main in-service concern is to ensure careful handling: sharp knocks damage the coating.