

SECTION 1, CHAPTER 7

CORROSION

List of Contents

	Para.		Para.
Introduction	1	Chromate Treatment	29
Surface Corrosion	3	Phosphating	32
Galvanic Action	5	Cementation	33
Intercrystalline Corrosion	6	Hot Dipping	34
Prevention of Corrosion	8	Metal Spraying	35
Remedial Action	11	Stove Enamelling	36
ANTI-CORROSION PROCESSES		Painting	39
Introduction	22	Organic Treatment	40
Electro-Plating	23	Special Protectives	41
Anodic Treatment	24	Protection in Storage	42

List of Illustrations

	Fig.
Anodic Bath	1

Introduction

1. A tradesman must be constantly aware of the damage that can be done by corrosion, and must at all times take precautions and instant remedial action to combat this widespread menace. Equipment manufactured for use in the Royal Air Force is produced to rigid specifications, therefore, from the design and production angles, all necessary anti-corrosion precautions and treatment will have been applied, and the job of the tradesman is to maintain this efficient state.

2. Corrosion is the destructive conversion of metals to metallic oxides and salts which neither resemble nor possess the physical properties of the base metals. The conditions under which corrosion may occur are many and varied, but it may be stated that the cause is primarily due to electro-chemical action. An example of this action is provided in an electric cell, in which a circuit is produced by suspending two different substances, two metals for instance, in a dilute chemical solution. When the circuit is completed, one metal (the anode) very gradually dissolves in the solution, and an electric current

flows through the solution from the dissolving metal to the other metal. A piece of metal exposed to moist atmospheric conditions behaves similarly, since impurities in the moisture, fumes, or contact with some other metal causes a slight difference of electrical potential, thus producing a minute electric current and corrosion of the anodic metal. This example does not provide the complete answer as there are so many variable factors which are likely to influence the start, course and final result of corrosion. Some metals have a greater tendency to corrode than others.

Surface Corrosion

3. Surface corrosion is caused by exposure to the atmosphere: becoming more pronounced in a moist atmosphere, even more rapid with alternate moist and dry conditions, and being greatly accelerated by high temperature. This is the most common form of corrosion and is readily detected by the difference between the products of corrosion and the original metal.

4. Corrosion on steel, commonly known as rust, is reddish-brown in colour; on alumin-

ium and its alloys it is a white or grey powder, and on copper it shows as a greenish discolouration. Corrosion reduces the thickness of the base metal and thus weakens the structure; the surface finish is also roughened or pitted. If the corrosion is such that the metal has not been weakened, it may be removed and suitable protective treatment applied. If the corrosion has caused pitting or has penetrated to such a depth that the part is weakened and below the limit of size, the part must be rejected.

Galvanic Action

5. This form of corrosion is similar in appearance to surface corrosion, but it is caused by different kinds of metal being in contact with each other. When in contact, dissimilar metals such as steel and duralumin, or the same metal in different heat treated states, e.g. annealed and normalized duralumin, readily corrode due to moisture and electrolytic action. The joining of dissimilar metals is not advisable, but where this is unavoidable, special protective compound must be spread over the surfaces before the parts are bolted or riveted together.

Intercrystalline Corrosion

6. This type of corrosion is the most dangerous because it is very difficult to detect, no corrosion products being visible to the naked eye. It occurs in alloys, attacking the metal in depth along the crystal boundaries, and may only be visible through a magnifying glass as a thin crack. The spread of the corrosion going entirely beneath the surface, weakens the ultimate strength and destroys the endurance of the metal in a very short period. Intercrystalline corrosion is caused by interaction between the elements of the alloy.

7. Numerous experiments have proved a definite connection between the last heat treatment and intercrystalline corrosion, and it has been found that this type of corrosion does not occur in a metal which has been correctly heat treated. Light alloys and some stainless steels are susceptible to this form of corrosion, but, by strict and accurate control of the heat treatment process, the possibility of attack by corrosion can be reduced to an absolute minimum.

Prevention of Corrosion

8. There are many varied processes used to combat corrosion, some of which will be described in more detail later in this chapter. The following is a broad outline of some of the methods used to limit corrosion:—

(a) Making the metal form its own protective coating, e.g. anodizing aluminium and its alloys, chromating magnesium and its alloys, and coslettizing steel.

(b) Covering the surface with another metal less likely to corrode, or using a covering metal which will corrode without affecting the metal it is covering, e.g. galvanizing steel, hot-rolling aluminium on to duralumin (alclad), and metal dipping and spraying.

(c) Giving the surface a protective coating, e.g. enamel, paint, varnish, grease or lanolin, depending on the material to be protected.

9. Such processes as the anodizing of aluminium and its alloys, the chromating of magnesium, etc., provide a very thin protective film. To give added protection against corrosion, these treatments are usually covered with one of the protective coatings (c).

10. If the anti-corrosive film or protective finish is scratched or damaged, not only does the exposed metal corrode, but the corrosion may also spread under the surrounding film. Care must be taken at all times, therefore, to prevent surfaces from being scratched or damaged. Where damage to the anti-corrosive treatment exists, and it is impracticable to have the whole part removed for retreatment, the best possible substitute should be used which would consist of applying protective finish, oil or grease, depending on the part to be treated; this should be done as soon as possible so as to prevent the onset of corrosion.

Remedial Action

11. When repairing damaged parts, corroded areas must be regarded as damaged areas and included in the damage classification. Great care must be taken to ensure that no corrosion remains undetected, especially where it will not normally be seen. For example, surface corrosion may not be visible when the

metal is covered by protective finish, but it may be detected by pressing the protective finish with the finger when the paint or enamel will flake off. "Lifting" or "bubbling" of the protective finish usually conceals corrosion. The extent of corrosion of rivet heads can be determined by rubbing the heads with a piece of hardwood.

12. Once corrosion is detected, inspection and assessment must be made to decide whether the part will be serviceable after the corrosion has been removed; if it is considered that it will be undersize or there is any doubt, then the part must be rejected.

13. Every trace of corrosion must be completely removed before attempting treatment of a corroded part, otherwise corrosion of the affected part will very soon re-occur. The method of removal of corrosion will depend upon the particular circumstances, but if there is any doubt the N.C.O. i/c Section should always be consulted. Mechanical methods such as sand blasting, filing, polishing with abrasive cloth, or rubbing with a wire brush, are often used but may not always be satisfactory; when the parts are complicated in shape or have large surface areas, rust removing solutions, Types D and E, are to be used.

14. **Rust Removing Solution, Type D.** This is basically a solution of phosphoric acid in water, and it is used to remove rust from heavily corroded ferrous metals after they have been degreased. It should normally be used in its concentrated form and should not be further diluted with water. Since it contains butyl alcohol the solution should not be heated.

15. **Rust Removing Solution, Type E.** This is similar to, but weaker than Type D, and does not contain butyl alcohol; consequently it may be heated up to 60°C. to accelerate its action. It is used for derusting less severely corroded ferrous metals which do not need the stronger solution.

16. **Precautions in Use.** The solution must not be used in galvanized, aluminium or zinc containers; these should be of glass, or lined with lead or rubber, and must be so placed that there is no risk of the solution being spilled. These solutions must not be brought into contact with non-ferrous metals,

high tensile or surface hardened steels, thin leaf springs, or steel that is less than 0.020 in. thick. Composite components with parts other than ferrous metals should have such parts protected with wax.

17. **After Use.** Components which have been treated with derusting solution should be washed thoroughly in clean cold water and then rinsed in clean hot water. Great care must be taken to ensure the removal of all the solution. Joints, seams, etc., should be tested with blue litmus paper; if acid is present the blue litmus will turn red. If everything is satisfactory, the components should be washed in a warm aqueous solution of sodium chromate in the proportion of $\frac{1}{2}$ lb. of chromate to 100 gallons of water. The parts should then be dried in warm air, and, when thoroughly dry, the surfaces should be painted or coated at once with a temporary rust preventative, such as lanolin, to prevent the re-formation of rust.

18. Light rusting of ferrous parts may be removed in the following way:—

- (a) Clean with metal degreasing liquid.
- (b) Apply paint remover, and when the protective finish has softened, remove it with a hardwood scraper.
- (c) Remove the corrosion with a cloth soaked in kerosine, or by scratch brushing.
- (d) Again clean the affected area with metal degreasing liquid and wipe dry.
- (e) Apply primer and synthetic resin protective finish, or the protective finish as stated in the Vol. 6.

Notes 1. Although kerosine will remove corrosion, it will also cause corrosion if left on the part, therefore, all traces of the kerosine must be removed before applying a protective finish.

2. Ferrous parts which are oiled or greased for protection need only a sufficient new coating of the lubricant.

19. **Aluminium and Aluminium Alloys.** Corroded rivets and tubing must be renewed. Lightly corroded sheet, and the surfaces of parts should be treated as follows:—

- (a) Clean with metal degreasing liquid.

- (b) Remove protective finish with paint remover as described in para. 18(b).
- (c) Remove the corrosion with a cloth soaked in dope thinners or kerosine.
- (d) Again clean the affected area with metal degreasing liquid and wipe dry.
- (e) Treat with Deoxidine 202, and apply primer and finish to conform with the the surrounding area.

Note. Internal metal surfaces may be treated with liquid rust preventive instead of primer and finish.

20. Magnesium and Magnesium Alloys. When removing old protective finish in the corroded area, care must be taken to prevent damage to the chromate film. A stiff fibre brush should be used in preference to paint remover. Lightly corroded parts should be treated as follows:—

- (a) Clean with metal degreasing liquid.
- (b) Remove protective finish with a stiff fibre brush, or soften with a paint remover and scrape lightly.
- (c) Again clean the affected area with metal degreasing liquid and wipe dry.
- (d) Remove corrosion with a stiff fibre brush, and then by swabbing with a solution of 2 oz. of chromic acid crystals dissolved in one pint of water, acidified by the addition of 8 drops of sulphuric acid.
- (e) Wash thoroughly with clean water.
- (f) Immediately after washing, swab with solution of 2 oz. of selenious acid crystals dissolved in one pint of water. This should be applied with cotton wool or soft rag tied to a stick until a brown or brown-black colour appears on the surface of the metal.
- (g) Finally, apply two coats of yellow magnesium alloy primer, allowing the first coat to dry before applying the second, and then one coat of finish to conform with the surrounding area.

21. Safety Precautions. Paint remover and the acids used in the treatment of metal surfaces are dangerous to health, therefore care must be taken not to inhale the fumes or allow the materials to touch the skin. Appropriate protective clothing, goggles, respirator, and rubber gloves should be worn, and prophylactic ointment used as

directed when working with such materials. The cotton wool or rags with which the solutions are applied should be burnt after use. If any of the solutions splashes on to the skin it must be washed off immediately. Always thoroughly wash the hands with soap and water after using the materials, especially before eating food.

ANTI-CORROSION PROCESSES

Introduction

22. As stated previously there are many processes that are employed for the purpose of resisting corrosion, and some of the more commonly used methods are described in the following paragraphs. The treatment is normally done by the manufacturer before the part is received for Service use, but when parts have been manufactured or modified locally, similar approved protection may need to be applied.

Electro-Plating

23. The basic principle of electro-plating is as follows. The article to be plated and the plating metal are immersed in a solution of a suitable electrolyte. The article is connected to the negative pole and the plating metal to the positive pole of a direct current electricity supply. On completing the circuit, and under correct conditions, a coating is transferred to the article at the cathode (—) from the metal at the anode (+). The most commonly used metals are nickel, chromium, cadmium, zinc, copper and tin.

Anodic Treatment

24. This process is applied to aluminium and aluminium alloys, and is similar in principle to electro-plating, but the current is passed between two electrodes, neither of which dissolves. In this instance, splitting of the electrolyte into hydrogen and oxygen is the important factor, the hydrogen forming at the cathode and the oxygen at the anode. The oxygen combines with the anode, which is the part being treated, to form a continuous surface film consisting mainly of hydrated aluminium oxide, which has a high resistance to corrosion. Two common electrolytes used are dilute chromic acid and dilute sulphuric acid.

25. Chromic Acid Method. The electrolyte consists of 3 per cent. (by weight) of chromic

acid in distilled water. Brass anode bars are fitted across the top of the tank, from which the parts to be treated are suspended and immersed in the electrolyte (Fig. 1). The tank itself may be lined with stainless steel plates and serve as the cathode, although stainless steel plates suspended from a cathode bar are sometimes used. The bath is worked at a temperature of $40^{\circ}\text{C} \pm 2^{\circ}\text{C}$., and the electrolyte must be gently agitated, this often being done by a rotating paddle. A thermometer is used to check the temperature, which can be regulated by operating a cooling/heating system consisting of a cold or hot water coil fitted the length of the bath. The direct current supply used to operate the bath ranges from 0 to 50 volts.

bath must be gradually increased, in steps of not more than 5 volts, from 0 to 40 volts. The voltage must be maintained at 40 volts for the next 20 minutes. During the next 5 minutes, gradually increase the voltage to 50 volts and then maintain it at 50 volts for a further 5 minutes, at the end of which the current should be switched off; the total time required is 40 minutes.

(b) Immediately after treatment, the parts are swilled in clean running water, followed by washing in hot water and drying. The quality of the film can be determined by appearance, feel, dye and electrical tests. The dye test consists of marking

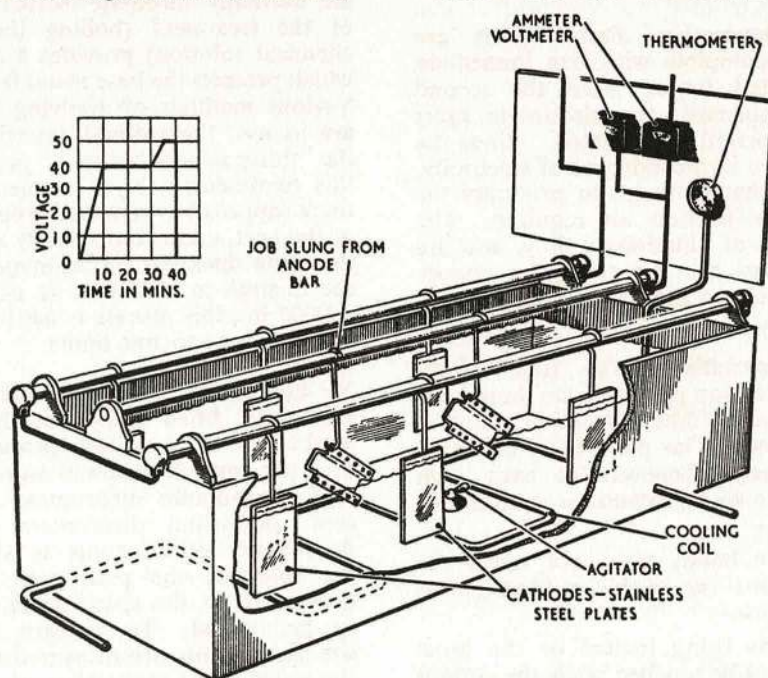


Fig. 1. ANODIC BATH

(a) **Process.** Before treatment, use a degreasing agent to thoroughly clean the parts and then wash them in clean running water. After cleaning, they must not be touched with the bare hands but should be suspended by aluminium wire from the anode bar and immersed in the electrolyte. With the bath at the correct temperature and the agitator operating, the current should be switched on and, during the first 10 minutes, the voltage across the

the parts with an indelible pencil or cheap dye; if the film is satisfactory, the dye cannot be removed by the use of damp cloth.

26. Sulphuric Acid Method. The equipment is similar to that used for the chromic acid method, but the tank is lead-lined, the cathodes are of lead instead of stainless steel, and the direct current supply does not exceed 14 volts. The electrolyte consists of 18 to

22 per cent. (by volume) of sulphuric acid in distilled water. The temperature of the electrolyte is maintained at $20^{\circ}\text{C.} \pm 2^{\circ}\text{C.}$, and the process consists of holding the voltage constant within the range of 12 to 14 volts for a period of not less than 15 minutes, and not more than 30 minutes. Immediately after treatment, the parts are washed thoroughly in clean running water, immersed for a few seconds in clean hot water and dried. After ascertaining if the film is satisfactory (para. 25b), the parts, if not to be dyed, are immersed in a solution of potassium dichromate, sodium carbonate and water at a temperature of 94°C. to 98°C. for 5 to 10 minutes; this seals the film and increases resistance to corrosion.

27. Double Immersion. Parts which are too large to complete with one immersion may be treated twice; when the second portion is immersed, the electrolyte must overlap the portion first treated. Since the anodic film is a non-conductor of electricity, special clips, sharp enough to penetrate the film of the first portion, are required. The clips are made of aluminium alloy, and are suspended from the brass bar by copper wire, which must be kept clear of the electrolyte.

28. Safety Precautions. The fumes from the anodic oxidation processes are dangerous to health, and a fume extraction plant is always provided. This plant must be working continuously whenever the bath is in use. The following precautions should also be observed:—

(a) The bare hands must not touch the acid solution; serviceable rubber gloves must be worn.

(b) The parts being treated or the brass bars must not be touched while the current is "ON". Switch off the current before removing parts from the bath.

(c) Vapour from the bath must not be inhaled.

(d) To minimize the danger from spray or splashes, the level of the electrolyte must be several inches below the top of the bath; the level of the electrolyte is usually indicated on the side of the bath.

Notes. 1. The chromic acid method is not suitable for use on aluminium alloys containing more than 5 per cent. of

copper. The sulphuric acid method is not suitable for use on parts having riveted, lap or folded joints, nor on aluminium foil less than 0.010 in. thick.

2. Anodic treatment, if it is correctly done, will cause a very slight increase in the volume of the treated part. Prolonged or improper treatment in the sulphuric acid method may, however, cause serious loss of metal.

Chromate Treatment

29. Magnesium and magnesium alloys and zinc when exposed to humid conditions are normally chromate treated. The action of the treatment (boiling the parts in a chemical solution) provides a chromate film which protects the base metal from corrosion. Various methods of applying the treatment are in use; the method described is termed the "thirty minute hot bath" process. During this treatment, a layer of metal 0.0002 in. thick (approx.) is removed from the surfaces of the part, and is replaced by approximately the same thickness of chromate film. Since the change in thickness is not more than 0.0005 in., this process is used for parts that are machined to fine limits.

30. Equipment. A clean aluminium or mild steel tank, fitted with a heating system, is used to contain a solution in water consisting of 3 per cent. ammonium sulphate, 1.5 per cent. ammonium dichromate and 1.5 per cent. potassium dichromate (by weight). A quantity of ammonia is also added to the solution, the percentage (by volume) depending on the specification of the metal to be treated. To prepare the solution, the constituents are measured and added to the water in the tank; after stirring, the tank is heated to maintain the solution at boiling point.

31. Process. After thorough cleaning, the parts must not be handled but should be attached to wire, or supported in magnesium or aluminium baskets attached to wire, and then immersed in the boiling chromate solution for a period of 30 minutes. After treatment, the parts are removed from the bath and immediately washed in warm water and dried in a current of warm air. The chromate film is very thin; it is, there-

fore, necessary to coat the parts, immediately after drying, with primer and protective finish to protect the film.

Note. The quality of the chromate film is judged by its colour, which ranges from straw to jet-black, depending on the specification of the alloy treated.

Phosphating

32. In this process the work is immersed in a bath of acid phosphate solution which is maintained at near-boiling point. The solution reacts with the metal at the surfaces of the work and, after a period of time depending on the degree of corrosion resistance required, the surface metal is converted into a metallic phosphate. Before the application of a sealing medium such as paint or enamel, correctly treated parts have a fine crystalline grey surface. Phosphating is applied to ferrous metals, and is known as "parkerizing", "walterizing", "jenolizing", "coslettizing", "ravelizing", depending on the proprietary process used.

Cementation

33. When this type of process is used the work is heated while in close contact with finely divided particles, or dust, of another metal, such as zinc (sherardizing) and aluminium (calorizing). Sherardizing is similar to case-hardening, in that it causes steel to absorb zinc, instead of carbon, and thus becomes rust-proof.

Hot Dipping

34. In this process the article to be treated is first thoroughly cleaned, and then immersed in a bath of molten metal—zinc, tin or lead being most commonly used as the coating metal. When zinc is employed as the coating metal the process is termed "galvanizing".

Metal Spraying

35. Metals or alloys capable of being drawn into wire can be melted and sprayed, with the aid of a special pistol, at high velocity on to previously prepared metal surfaces. The sprayed metal adheres very firmly to the base metal, the union being mechanical as distinct from that of an alloy. Although the wire is melted at high temperature the spraying action cools the deposited metal, and the process does not cause heating of

the treated article. The matt surface obtained by this form of metallization is ideal for painting or enamelling. Normally it is difficult to deposit aluminium electrolytically but it can be sprayed, such a process being known as "aluminizing". Brass, copper, nickel, zinc, etc., are other metals which are used to coat the base metal by this process.

Stove Enamelling

36. The stove enamel process is used for the protection of steels, and aluminium and its alloys. It consists of applying enamel to the parts to be treated, and heating in an oven to harden the coat. Two specifications of stoving enamel may be used.

37. **Stoving Enamel—D.T.D.56.** This specification, consisting of two coats, is suitable for metals that are not affected by the high temperature (170°C.) used in the process. The parts are first thoroughly cleaned by a degreasing agent—steel parts may be shot or sand blasted. To ensure that the parts are dry, they are heated in the stove for a few minutes then, while still warm, dipped, sprayed or brushed with enamel and suspended by wire from hooks. After removing any blobs of enamel with a soft brush, the parts are transferred to the stove and baked (stoved). Each coat is stoved for 2 hours at 170°C. This temperature must not be exceeded, otherwise, there is danger of melting soft solder or tinning that may have been previously applied to the part. After each heating the part is cooled slowly, preferably in the stove after turning off the heat.

38. **Stoving Enamel—D.T.D.235.** This specification, termed low temperature stoving enamel, consists of a priming coat and a finishing coat, each of which is stoved for 2 hours at 125°C. It is used on metals, especially light alloys, where the higher temperature (170°C.) of D.T.D.56 might have a detrimental effect on the properties of the material. The process is similar to that described for D.T.D.56.

Painting

39. Metal surfaces which are not subject to abrasion may be suitably protected for appreciable periods by means of special rust resisting paints or enamels, etc. These consist of protective materials held in liquid sus-

pension, and are applied by brushing, spraying or dipping. They are often used to give protection to thin film anti-corrosive treatments.

Organic Treatment

40. Oils, greases, lanolin, mineral jelly, etc., are often used as added protection to previously applied anti-corrosive treatments. They are also used as temporary anti-corrosive treatments.

Special Protectives

41. It is outside the scope of these notes to describe in detail the various special protectives which are used in the Royal Air Force for particular applications. These include procedures for the preservation of cylinders and valve gear of assembled engines, tools, machine tool tables, etc. Nevertheless, it must always be borne in mind that some of these protectives contain

chromates and other toxic ingredients which, unless proper precautions are taken, will have harmful effects on the health of personnel employed on their application and removal.

Protection in Storage

42. Frequent and regular servicing of equipment in use is a safeguard against corrosive attack. Stored equipment is inspected less frequently and in consequence protection against corrosion is a problem of importance. Rust preventive sealing compounds, inhibitor grease, lanolin and wrapping with waterproof paper and fabrics are the materials used in approved methods of corrosion-resistant treatment applied to equipment in storage. Bulky equipment is stored in sealed cases, metal containers or plastic protective coatings, in which the humidity content is reduced to a minimum by moisture absorbent chemicals (desiccants).

This file was downloaded
from the RTFM Library.

Link: www.scottbouch.com/rtfm

Please see site for usage terms,
and more aircraft documents.

