

Aircraft Material Specification
UNSATURATED POLYESTER RESINS
(for low pressure laminating purposes)

NOTE 1.—This specification is one of a series issued by the Ministry of Aviation either to meet a limited requirement not covered by any existing British Standard (Aircraft Series) or to serve as a basis for the inspection of materials, the properties and uses of which are not sufficiently developed to warrant submission to the British Standards Institution for standardisation.

SECTION 1

1. Scope

The materials covered by this specification shall be synthetic resins of the unsaturated polyester type, together with a catalyst and an accelerator (if required) which, when mixed together in accordance with the manufacturer's instructions, shall be suitable for use in the manufacture of glass fibre reinforced laminates.

2. The resins, to which this specification applies fall into two main types:—

Type M—For use where mechanical properties only are of primary importance.

Type E—For use where both mechanical and electrical properties are of primary importance.

Both types are sub-divided, according to the high temperature resistance, into five classes as follows:—

Classes M.A. and E.A.—For use at temperatures not exceeding 70°C.

Classes M.B. and E.B.—For use at temperatures not exceeding 90°C.

Classes M.C. and E.C.—For use at temperatures not exceeding 150°C.

Classes M.D. and E.D.—For use at temperatures not exceeding 200°C.

Classes M.F. and E.F.—For use at temperatures not exceeding 260°C.

The type and class required must be stated on all drawings and contracts.

3. This specification shall be applicable to resin systems as supplied by resin manufacturers. These will include not only unmodified polyester resin systems but also systems which contain thixotropic and/or fire-proofing additives, pigments and fillers. These modified systems must comply in all respects with the requirements of this specification.

SECTION 2

4. Definitions

The following definitions apply to some of the terms used herein.

4.1 *Low pressure laminating.* A process of laminating or moulding in which the applied moulding pressure is within the range 0 to 200 lb./sq. in.

4.2 *Unsaturated polyester resin.* A solution in styrene (or other reactive monomer or mixture of monomers) of a polymer in which the structural units are linked by ester groupings obtained by the condensation of one or more polycarboxylic acids (and if desired a minor proportion of a monocarboxylic acid) with one or more polyhydric alcohols some or all of which may be ethylenically unsaturated (and if desired a minor proportion of a monohydric alcohol).

4.3 *Catalyst.* An additive which increases the rate of curing of an unsaturated polyester resin.

4.4 *Accelerator.* An additive which enhances the effect of a catalyst in increasing the rate of curing of a polyester resin. The term "Promotor" is sometimes used in this sense.

4.5 *Batch.* A quantity of material so designated by the supplier and substantially uniform in quality.

SECTION 3

5. Related documents

Reference is made in this specification to the following:—

B.S.188: 1957—Method for the determination of the viscosity of liquids in absolute units.

B.S.572: 1950—Interchangeable conical ground glass joints.

B.S.733: 1952—Density bottles.

B.S.2782—Methods of testing plastics Part 3: 1957—Mechanical properties.

Part 5: 1958—Miscellaneous methods.

B.S.3L.17—99 per cent aluminium sheets (soft).

B.S.STA 18—Services specification for brass strip for Q.F. and S.A. cartridge cases and for caps.

D.Eng.RD.2487—Lubricating oil, aircraft turbine engine, synthetic type.

D.T.D.406—De-icing fluid.

D.T.D.585—Hydraulic oil-petroleum base.

D.T.D.626—Magnesium-zinc-zirconium alloy sheets.

D.T.D.779—Inhibited ethylene glycol.

D.T.D.904—Cadmium plating.

D.T.D.911—Protection of magnesium-rich alloys against corrosion.

D.T.D.5518—Glass fibre fabric ("E" glass).

SECTION 4

6. Instructions for use

The manufacturer shall supply instructions detailing the proportions in which each recommended combination of resin and catalyst or resin, catalyst and accelerator, shall be mixed together with methods of use and cure for impregnating and laminating glass fabric. Any necessary precautions to be taken when handling, mixing or curing, shall be stated. The manufacturer shall state the type of finish on the glass fabric used for the preparation of test specimens as required in Clause 7.3.

The manufacturer's instructions shall include:—

- 6.1 The storage (shelf) life of each of the unmixed materials at 25°C maximum and 40°C maximum, when stored in the original sealed container. It is emphasized that throughout the periods stated to be the storage lives the resin and resin system must conform fully with the requirements of this specification.
- 6.2 The time, temperature and pressure required for curing each mixed resin system after laminating and the time, temperature and pressure for post cure, if any, is required.
- 6.3 The usable life (pot life) of each mixed resin system, giving the approximate maximum time in an ambient air temperature of 25°C, during which each mixed system will remain fit for use and comply with the requirements of this specification after laminating and curing.

The bulk (volume and shape of container) and conditions of test shall be stated.

SECTION 5

7. Type M Resins—Type Approval.

Before any particular manufacturer's materials are supplied as complying with the requirements of this specification, the manufacturer must obtain type approval.

Applications for type approval shall be submitted to the Director of Chemical Inspection, War Office, H.Q. Building, Royal Arsenal, Woolwich, London, S.E.18. together with:

- 7.1 Evidence that the materials comply with the requirements specified herein.
- 7.2 Samples of the materials for which approval is sought together with:
 - 7.2.1 Details of composition if required by D.C.I. for special applications.
 - 7.2.2 The company reference number (if any).
 - 7.2.3 Full instructions for use (two copies), see Section 4.

(Attention is drawn to the need for supplying a separate container of resin for use in ensuring conformity with Clause 6.1).

- 7.3 Test laminates prepared in accordance with the information supplied in complying with Clause 6. Such laminates shall have a total area of at least 4 sq. ft. and one dimension of each piece must be at least 1 ft. Untrimmed laminates to this latter dimension are acceptable.
- 7.4 A list of nominal values for the properties referred to in Table 1 when determined by the methods described in Appendices 1-5. The nominal values proposed shall be to the satisfaction of D.C.I. In respect of gelation times it is necessary to submit nominal values for both temperatures only when the resin is designed for use both cold and hot. The tolerances permitted on the nominal values shall be as shown in Table 1.

TABLE 1

| Property | Appendix | Tolerance |
|-------------------------------------------------------------|----------|------------------------|
| Specific gravity at 25°C | 1 | ± 0.01% |
| Viscosity at 25°C | 2 | ± 30% |
| Acid value mg KOH/g | 3 | ± 4 |
| Gelation time at 25°C | 4 | ± 30% |
| Gelation time at 82°C | 5 | ± 30% |
| Change of viscosity within stated storage life | 2 | ± 30% of initial value |
| Change in gelation times within stated storage life | 4 or 5 | ± 30% of initial value |

7.5 Type approval must be obtained in respect of each resin/catalyst or resin/catalyst/accelerator system proposed.

8. Type Approval Tests

8.1 The test results obtained on the samples of materials supplied in accordance with Clause 7.2 must comply with the requirements of Clause 7.4 and the results of the tests obtained on the test laminates supplied in accordance with Clause 7.3 must comply with the requirements of Clause 8.2.

8.2 The properties of a laminate, made by the method described in Appendix 7 and determined by the relevant methods described in Appendices 8-15 shall comply with the requirements listed in Table 2 and Clause 9.

8.2.1 The samples shall show no cracking, crazing, delamination or any other visible deterioration after exposure or immersion cycles.

TABLE 2

| Test | Test Requirement | Test Method Appendix |
|--------------------------------------------------------------------------|-----------------------------------------|----------------------|
| (a) Flexural strength, lb./sq. in. | 55,000 (min.) | 8 |
| (b) Initial modulus of elasticity in flexure | To be recorded | |
| (c) Flammability, in./min. | 1.0 (max.) | 9 |
| (d) Water resistance, absorption, mgms, | 80 (max.) | 10 |
| (e) Water resistance, leaching, mgms. | 5 (max.) | 10 |
| (f) Glass content, per cent | To be recorded for each laminate tested | 11 |
| (g) Flexural strength, after water immersion, lb./sq. in. | 45,000 (min.) | 12 |
| (h) Initial modulus of elasticity, after water immersion | To be recorded | |
| (j) Weather resistance, flexural resistance, lb./sq. in. | 45,000 (min.) | 13 |
| (k) Weather resistance, initial modulus of elasticity | To be recorded | |
| (l) Resistance to fluids listed in Appendix 14 | | |
| Weight change, per cent | ± 0.5 | 14 |
| Retention of flexural strength, per cent of original value | 80 (min.) | 14 |
| (m) Freedom from corrosive substances using following test metals: | | |
| (i) Mild steel, cadmium plated and passivated to D.T.D.904 | Loss in weight in mgms. to be recorded | 15 |
| (ii) Brass, B.S. STA.18 | " | 15 |
| (iii) Aluminium, B.S.3 L17 | " | 15 |
| (iv) Magnesium alloy to D.T.D.626 with D.T.D.911. Bath 3 treatment | " | 15 |

9. Resistance to elevated temperatures

9.1 For the determination of resistance to elevated temperatures, the temperature used in the following tests shall be the maximum for the particular grade of resin under test. A tolerance of $\pm 2^{\circ}\text{C}$ shall be permitted on test temperatures up to and including 150°C and $\pm 5^{\circ}\text{C}$ for higher test temperatures.

9.2 The flexural strength determined at the maximum temperature for the appropriate grade and otherwise as described in Appendix 8, after exposure to the test temperature for 30 ± 1 minutes shall be not less than 20,000 lb./sq. in., and after 192 ± 4 hours, shall be not less than 25,000 lb./sq. in.

9.3 After exposure to weathering as described in Appendix 13, the flexural strength shall be determined at the maximum temperature for the appropriate grade and otherwise as described in Appendix 8.

After exposure to the test temperature for 30 ± 1 minutes the flexural strength shall be not less than 15,000 lb./sq. in., and after 192 ± 4 hours shall be not less than 20,000 lb./sq. in.

10. Routine inspection

10.1 A representative sample shall be drawn from each batch of resin.

10.2 The samples shall be free from contamination.

10.3 The specific gravity, viscosity, acid value and gelation times at 25°C and at 82°C , if appropriate, shall be in accordance with the requirements of Clause 7.4.

10.4 The Inspection Authority may at any time require the manufacturer to test for compliance with any of the requirements of this specification.

11. Keeping Qualities

At any time during their stated storage life, the materials shall comply with all the requirements specified herein, provided that they have been stored in their original sealed containers under the temperature conditions stated on the containers.

SECTION 6

12. Type E Resins

General. The materials shall comply with all the requirements specified in Sections 4 and 5 (Clauses 6-11) and shall be formulated to meet the requirements of Clause 13.

Type approval procedure shall be applicable to this class of resin.

The limits quoted refer to the standards which it is desired to achieve but it may be found that existing electrical grade resins produce laminates which do not conform to the requirements of Clause 13.

For the present, if it is the intention to record all results obtained and any decision as to whether materials giving test results outside the specification limits can be accepted will rest with D.C.I.

It is known that the values obtained are affected by the resin/glass ratio in the test specimens but it is a very important requirement that the changes which occur during storage under humid conditions should be as small as possible.

13. Permittivity and power factor

The permittivity and power factor of a laminate when determined by the method described in Appendix 16 shall be as follows:—

| Test | Before storage | After storage for 21 days at 90 ± 2% R.H. at 20 ± 2°C |
|--------------|----------------|------------------------------------------------------------------------------------|
| Permittivity | 4.4 (max.) | 5.5 (max.) and not more than 25% greater than the value obtained before storage. |
| Power factor | 0.020 (max.) | 0.025 (max.) and not more than 25% greater than the value obtained before storage. |

SECTION 7

14. Marking—Each container shall be clearly marked with:—

- 14.1 This specification number and the resin type and class.
- 14.2 The name or trade symbol of the manufacturer.
- 14.3 The manufacturer's grade reference and batch number.
- 14.4 The maximum and minimum temperatures at which the contents should be stored.
- 14.5 The date by which the contents of the containers should be used.

APPENDIX 1

Method for the determination of specific gravity at 25/25°C

The method shall be as described in B.S.733, Appendix B.

Other methods e.g. Westphal balance or simple hydrometer may be used if they can be shown to give the same result. In cases of dispute the method described in B.S.733 shall be used.

APPENDIX 2

Method for the determination of viscosity at 25°C

The viscosity of the resin at 25°C shall be determined according to B.S.188.

APPENDIX 3

Method for the determination of acid value

Solutions required: N/10 alcoholic potassium hydroxide.

Indicator—Thymol Blue or Phenolphthalein.

Solvent—Methyl ethyl ketone, chloroform, or acetone.

Apparatus required: Usual titration apparatus.

Procedure. A blank determination shall first be carried out by titrating 25 ml. of solvent with N/10 alcoholic potassium hydroxide.

Approximately 1g of resin shall be weighed accurately into a dry 150 ml. conical flask and dissolved in 25 ml. of solvent. Two or three drops of indicator shall be added, and the solution titrated with N/10 alcoholic potassium hydroxide.

The acid value of the resin shall be calculated as follows:

if: Blank titration = B ml.

Sample titration = V ml.

Weight of sample = Wg.

Factor for N/10 alcoholic KOH = f.

then Acid Value = $\frac{(V-B) \times 5.6 \times f}{W}$ mg. KOG per g.

Two determinations shall be carried out and the mean recorded as the result.

APPENDIX 4

Method for the determination of gelation time at 25°C

Apparatus required*

1. 400 ml. beaker containing a quantity of lead shot to hold the beaker down when in water.
2. Piece of cork 1½ in. square × ¼ in. thick resting on the lead shot at the bottom of the beaker.
3. Cover for beaker made of thermal insulating material approximately ¼ in. thick having a central hole ⅜ in. diameter.

*NOTE: The apparatus known as the Techné Gel Timer has been found suitable for this test.

4. 3 in. square of aluminium foil (0.005 in. thick) folded to make a 1 in. \times 1 in. \times 1 in. open-topped cube.

5. A vertical, thin stainless steel rod 4 in. long, 0.12 in. diameter with a horizontal stainless steel disc $\frac{7}{8}$ in. diameter and $\frac{1}{16}$ in. thick attached symmetrically at one end (with highly viscous resins the diameter of this disc may need to be reduced) is connected through a simple mechanical device to an electric motor so that the disc can be moved up and down vertically. When the motor is switched on the spindle and disc descend $\frac{1}{2}$ in. in half a minute and then rise again, completing the reciprocation in one minute. An automatic device counts the number of reciprocations. A mechanical trip is arranged to cut out the motor when there is an appreciable increase in the resistance to the downward movement of the disc.

6. Water bath, thermostatically controlled at $25 \pm 0.2^\circ\text{C}$.

Method

The apparatus described in (5) above shall be clamped in such a way that the spindle can move vertically in the centre of the empty aluminium container resting on the cork pad in the beaker which is immersed in the water bath.

100 g. of polyester resin shall be catalysed in the proportions specified by the resin manufacturer and brought to a temperature of $25 \pm 1^\circ\text{C}$ stirring for at least 2 minutes. The accelerator shall also be brought to $25 \pm 1^\circ\text{C}$ and the correct amount as specified by the resin manufacturer shall be added to the catalysed resin and the whole stirred vigorously for at least 2 minutes. At the moment the accelerator is added to the resin the motor shall be switched on. The time taken to mix in the accelerator shall be recorded as part of the gelation time of the resin.

The aluminium container, in position in the beaker, shall be filled quickly with the resin/catalyst/accelerator mixture.

The apparatus shall be adjusted so that the disc is completely immersed in the resin during the complete reciprocation. At its highest position, the disc shall be at least $\frac{1}{4}$ in. below the surface of the resin.

The number of reciprocations completed when the motor stops shall be recorded and the mean of three such determinations shall be recorded as the gelation time of the resin system in minutes at 25°C . The size of disc used shall be stated.

APPENDIX 5

Method for the determination of gelation time at 82°C

Apparatus required

- A. 500 ml. round bottom flask (B34 neck, B.S.572: 1950).
- B. Adaptor (B34 joints with B19 side neck, B.S.572: 1950).
- C. 12 in. Liebig condenser with B19 female entry joint, B.S.572: 1950.
- D. 6 in. \times 1 in. test tube of heat resistant glass containing 6 to 7 g. of liquid paraffin.
- E. 6 in. \times $\frac{3}{4}$ in. test tube.
- F. Thin glass rod.

50 ml. of isopropyl alcohol (boiling point 82.4°C) shall be kept boiling in the flask A so that the temperature of the liquid paraffin in the test tube D which is placed within the flask is maintained at a temperature between 82°C and 82.5°C . 100 gm. of polyester resin shall be catalysed in accordance with the manufacturer's instructions. A layer of the resin approximately 1 in. deep shall be poured into test tube E which shall then be placed immediately within test tube D, a stop-clock being started at the moment test tube E is immersed in the liquid paraffin.

The glass rod F shall be placed immediately in the resin and the resin stirred by making one complete revolution of the rod around the approximate circumference of the resin in the tube E once every 15 seconds until gelation occurs.

The time within which the resin just ceases to be fluid, measured from the point of immersion in the hot liquid paraffin, shall be recorded and the mean of three such determinations shall be recorded as the gelation time of the resin system in minutes at 82°C .

APPENDIX 6

Method of conditioning prior to testing

The test sample or the specimens prepared therefrom shall be conditioned for not less than 4 days in an atmosphere with a relative humidity of 65 ± 5 per cent and a temperature of $20 \pm 2^\circ\text{C}$.

Except where otherwise required as part of the procedure of a particular test, all testing shall be carried out without removal of the material from this atmosphere.

APPENDIX 7

Method of Preparation of Test Laminate

The reinforcing material, shall be desized fabric S2/225/E to D.T.D.5518, finished by a process approved in D.T.D.900 and selected by the resin manufacturer.

The resin and catalyst or catalyst/accelerator system shall be mixed, used and cured in accordance with the resin manufacturer's instructions.

The glass fabric shall be dried in a ventilated oven for 1 hour at $100 \pm 5^\circ\text{C}$ before use. The fabric shall be cooled in a desiccator and used immediately on removal. The fabric is impregnated with the resin to give a final glass content of 60-65% of the total weight, the criterion for thorough impregnation being that the wet impregnated fabric is uniformly translucent. Both impregnation and building up of the laminate shall be done in a room temperature of 17 to 25°C . The warp direction of the fabric in any ply shall be parallel to the weft direction in the adjacent ply of the laminate.

A suitable method of impregnating the glass cloth and preparing the laminate is as follows:—

The weight of resin necessary to give the required resin content is calculated from the weight of glass cloth to be used. An excess (e.g. $1\frac{1}{2}$ times of this quantity of resin) necessary to produce void free laminates is then catalysed according to the manufacturer's instructions and is used immediately in the following way:—

Twelve squares of glass cloth 12 in. \times 12 in. are dried in the manner detailed above and then kept in a desiccator. A suitable flat plate about 15 in. square is covered with a sheet of regenerated cellulose film (0-0015-0-002 in. thick).

Approximately one twelfth of the catalysed resin is poured on to the cellulose film and the first layer of glass is then laid on it and pressed by using a knife blade, squeegee roller, or other device until the fabric is wetted with the resin and becomes evenly coated and uniformly translucent. This part of the process should occupy one or two minutes only.

The procedure is repeated with successive superimposed layers of glass fabric, each rotated through 90° in relation to the preceding layer. All layers shall be the same way up.

The top layer is immediately covered with a sheet of film followed by a second flat plate. "Stops" $\frac{1}{8}$ in. thick are placed between the upper and lower plates. Within 5 minutes of the completion of these operations the whole "build-up" is placed between the platens of a press which is closed and adjusted so that the plates are closed to the "stops" and held under a positive pressure of 5 to 10 lb./sq. in. during the curing schedule.

It is permissible to adjust the height of the "stops" to accommodate for variation in the weight of glass fabric actually used. By this method laminates may be prepared which have final glass contents near the mean of the permitted 60-65% range.

Any post-stoving treatment to the laminate shall be carried out according to the resin manufacturer's instructions.

APPENDIX 8

Method for the determination of flexural strength

From the laminate made in accordance with Appendix 7, five test pieces shall be prepared and their flexural strengths determined as specified in B.S.2782: Part 3: 1957, Method 304B. All sawing, machining and finishing operations used in preparing the test specimens shall be slow enough to avoid heating the specimen more than is absolutely necessary.

APPENDIX 9

Method for the determination of flammability

Three test specimens, each approximately 6 in. long by 0.5 in. wide shall be cut in any direction from the laminate prepared as described in Appendix 7. Each specimen shall be marked by scribing two lines 1 in. and 5 inches from one end. The other end shall be clamped in a support so that the longitudinal axis of the specimen is horizontal and the transverse axis inclined at 45° to the horizontal. Under the test specimen, there shall be clamped a piece of 18 mesh clean wire gauze about 5 in. square in a horizontal position $\frac{1}{4}$ in. below the edge of the specimen, and with about $\frac{1}{2}$ in. of the specimen extending beyond the edge of the gauze.

A bunsen burner ($\frac{7}{16}$ in. minimum outside diameter) with a luminous flame $\frac{1}{2}$ in. to $\frac{3}{4}$ in. in height shall be placed under the free end of the test specimen and adjusted so that the flame tip is just in contact with the specimen. At the end of 30 seconds, the bunsen flame shall be removed and the specimen allowed to burn. A stop watch shall be started when the flame reaches the first mark 1 in. from the end and the time observed when the flame reaches the second mark 4 in. away. The mean rate of burning determined from the three tests shall be calculated. If any specimen fails to continue to burn after the first ignition, the burner shall again be placed under the free end for a second period of 30 seconds immediately following the extinction of the first flame. If the specimen fails to continue burning again to the second mark, the sample shall be reported as self-extinguishing.

The tests shall be performed in a room or chamber protected from air currents but provided with means for venting the fumes from the burning specimens.

The mean of the 3 results shall be recorded as the flammability.

APPENDIX 10

Method for the determination of water resistance (absorption and leaching)

Three specimens shall be prepared and tested according to B.S.2782 Method 502G, with the additional requirement that if W_3 is less than W_1 , the difference shall be recorded and reported as water soluble matter.

APPENDIX 11**Method for the determination of glass content**

Three specimens each not larger than 1 in. square shall be cut from the test laminate prepared as described in Appendix 7. The sides shall be square to the faces and the edges shall not be frayed. Each specimen shall be weighed in a previously ignited, cooled and weighed crucible and then placed in a furnace at a temperature not higher than 340°C. The temperature of the furnace shall be raised to 550-600°C at a rate that will not cause blowing or loss of inorganic filler. Ignition shall be to constant weight of the crucible and contents, cooling being carried out in a desiccator. The glass content shall be calculated on the basis of the percentage of residue after ignition suitably corrected for residues from the additives (if any) incorporated in the resin.

The mean of three determinations shall be recorded as the glass content.

APPENDIX 12**Method for the determination of water resistance
(mechanical properties)**

At least three test pieces shall be immersed in boiling distilled water for two hours after which they shall be cooled in distilled water at ordinary room temperature for at least 15 minutes and a maximum time of 1 hour, dried with a clean cloth and their flexural strengths determined within 5 minutes of removal from the cold water.

The test pieces shall be prepared and tested as described in Appendix 8.

APPENDIX 13**Method for the determination of weather resistance**

Pieces of laminate, prepared as described in Appendix 7 and large enough to produce the test pieces described in Appendix 8, shall be exposed at 45° to the horizontal, facing south. At intervals of fifteen days the pieces of laminates shall be turned over and at intervals of one month they shall be exposed to the maximum temperature for the appropriate grade for 30 minutes. Where this temperature is higher than 100°C the laminates shall be pre-heated for 1 hour at 100°C before exposure to the higher temperature. One piece shall be so exposed for 3 months and another piece for 1 year. After being conditioned as described in Appendix 6, the flexural strengths of test pieces cut from the exposed laminates shall be determined as described in Appendix 8.

APPENDIX 14**Methods for the determination of the effects of immersion in fluids**

The fluids used shall be:—

- (i) D.T.D.585—Hydraulic oil—petroleum base.
- (ii) D.T.D.406—De-icing fluid.
- (iii) D.T.D.779—Inhibited ethylene glycol.
- (iv) Standard rubber test fluid, containing:—
30 parts by volume of pure toluene Analytical Reagent Quality.
70 parts by volume pure iso-octane (2,2,5 tri-methyl pentane).
- (v) D.Eng.R.D.2487—Ester lubricant.
- (vi) Chlorinated silicone fluid (Silcodyne).

Eighteen test pieces, i.e. 6 sets of 3, shall be prepared as in Appendix 7 measured and then weighed. The test pieces shall be immersed in the 6 fluids listed above, one set per fluid, for 24 hours at $25 \pm 2^\circ\text{C}$. Each test piece shall be totally immersed separately in 50 ml. of fluid by being placed on edge in a container and supported at an angle by the bottom and side wall of the container.

After removal from the fluid, the samples shall be wiped free of surface fluid and immediately weighed and the flexural strength determined as described in Appendix 8. The mean of the 3 determinations shall be recorded as the result. The retention of flexural strength shall be expressed as a percentage of the original flexural strength (Appendix 8).

APPENDIX 15**Methods of tests for the presence of corrosive ingredients**

The test metals shall be in the form of 2 in. square panels of (1) Mild Steel, cadmium plated and passivated to D.T.D.904, (2) Brass to B.S. STA.18, (3) Aluminium to B.S.3L.17 and (4) Magnesium alloy to D.T.D.626A treated according to D.T.D.911B Bath 3.

The panels shall be degreased before use by exposure to the vapour of boiling toluene (Analytical Reagent Quality), and shall be dried by exposure immediately upon removal from the vapour bath, by means of a stream of warm dry air.

The panels shall be allowed to cool and then weighed. The cleaned panels must not be touched by hand. Each test metal panel shall then be clamped to the side of a $1\frac{1}{2}$ in. square of resin laminate (prepared in accordance with Appendix 7) and the assembly exposed in a closed atmosphere of $90 \pm 2\%$ R.H. at $100 \pm 2^\circ\text{F}$ for six weeks.

Precautions must be taken to avoid contamination of the atmosphere in the system by the presence of laminates from more than one resin and also to avoid any risk of electrolytic effects between different metal panels.

After exposure the metal panels shall be separated from the laminate and examined for signs of corrosion both on the side that has had physical contact with the laminate and on the side which has been exposed to the controlled atmosphere.

If significant corrosion has occurred the panels shall be cleaned by the treatment given below and then reweighed and the loss in weight in milligrams shall be recorded.

- (1) *Cadmium plated sheet*.—any corrosion products shall be removed by means of a rubber policeman, preferably under running water. The panel shall be wiped with a cloth and washed with acetone and then dried in a current of warm dry air.
- (2) *Brass*.—The panel shall be immersed for five minutes in a 5% solution by volume, of sulphuric acid at 40-50°C and rubbed with a rubber policeman. It shall then be washed and dried as for cadmium plated steel.
- (3) *Aluminium*.—The panel shall be immersed for five minutes in concentrated nitric acid at 15-20°C and then removed and plunged immediately into a quantity of cold water. It shall then be washed and dried as for cadmium plated steel.

Magnesium alloy. Any loosely adherent corrosion products shall be removed by means of a bristle brush used under running water. The panel shall then be immersed in cold 10% ammonium chromate solution through which a stream of air is passing and left overnight. The panel shall then be removed and washed and dried as for cadmium plated steel.

APPENDIX 16

Methods for the determination of permittivity and power factor

Three test pieces cut from a laminate prepared as described in Appendix 7 shall be exposed for 3 hours to the maximum temperature appropriate for the class of resin under test, then allowed to cool to room temperature in an atmosphere with a relative humidity of 65 ± 5 per cent and a temperature of $20 \pm 2^\circ\text{C}$, under which conditions they shall be stored for at least 4 days.

The permittivity and power factor of test pieces shall be measured at a radio frequency of 9.375 megacycles per second. A wave-guide of internal cross section 0.900×0.400 in. shall be used to hold the test piece. For dielectric constant measurements a short circuit method shall be used and for power factor measurements an insertion method.

For the tests after storage at $90 \pm 2\%$ relative humidity and $20 \pm 2^\circ\text{C}$ test pieces shall be kept for 3 weeks in an enclosed chamber. All samples shall be tested within 15 minutes of removal from the chamber.

The mean of three determinations shall be recorded as the result.

Approved for issue,

N. J. L. MEGSON,

Director of Materials Research and Development (Air).

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