D.T.D.933A

Ministry of Defence
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OBSOLESCENCE NOTICE

All DTD specifications were declared obsolescent from 1st April 1999. All DTD 900 series approvals also lapsed at that time. The standards will no longer be updated but will be retained as obsolescent documents to provide for the servicing of existing equipment.

Further Guidance

The aim in declaring the specifications obsolescent is to recognise that the documents are not being updated and thus should be used with care by both purchaser and supplier. For example, a specification could contain valid technical information but may also contain type approval clauses that contradict procurement policy and/or use materials that do not comply with environmental legislation. The obsolescent specification can still be used as a basis for a purchase provided that the supplier and purchaser agree suitable changes to the specification within the purchase order/contract.

For the DTD 900 system, each specification has provided an MoD approved material and process. For these items, the declaration of obsolescence will constitute the termination of both the extant MoD approval and the continuing MoD assessment that had underpinned those approvals. Again, the technical content of the document remains valid and can be used by both purchaser and supplier as a basis for a contract but an acceptable (to the parties) approval/assessment procedure would be required.

MINISTRY OF AVIATION

D.T.D. 933A

(Superseding D.T.D. 933)

February, 1964

Aircraft Process Specification

GLASS FABRIC REINFORCED POLYESTER LAMINATES FOR AIRCRAFT STRUCTURES AND AIRBORNE RADOMES

SECTION I
INTRODUCTION

1. Scope

1.1 This specification defines certain requirements for the design and manufacture of laminates of glass fabric and polyester resin, and for sandwich composites in which skins of these laminates are used.

1.2 The standard specified is that required for radomes and dielectric windows, and Class 1 aircraft parts. (See Av.P.970).

SECTION II
INFORMATION TO BE SHOWN ON DRAWINGS

2. General

2.1 The Component drawing shall give the following information, either in detail or by reference to other documents.

2.1.1 The glass fabric and resin to be used, together with the details, including thickness of the core material in the case of sandwich structures.

2.1.2 Laminate thickness and the ratio of glass fabric to resin. (Clause 4).

2.1.3 The disposition and types of joints in the fabric reinforcement. (Clause 5).

2.1.4 Curing conditions. (Clause 6).

2.1.5 The surface coating required. (Clause 7).

2.1.6 Details of electrical, mechanical and structural test requirements, if any.

3. Materials

3.1 Glass Fabric

3.1.1 Except where the glass fabric is to function solely or partly as a spacer, Type 'E' Glass Fabric to B.S.S. 3396, selected from the list given in Appendix I., shall be specified.

3.1.2 The finishing process (or alternative finishing processes) for the fabric shall be stated. Only approved processes to the requirements of B.S.S. 3396, Part 3, Grade S or C may be used. Spacer fabric woven from yarn shall conform to B.S.S. 3396* and shall be finished with Grade S or Grade C finish in accordance with Part 3 of that Standard.

If the glass fibre for use as spacer is in mat, roving or roving fabric form it shall comply with B.S.S. 3496, (1962), Part 2, B.S.S. 3691 (1963), Part 2 or B.S.S.*, as appropriate. If the reinforcing fabric is finished to Grade S a silane keying agent shall be stipulated for the mat, roving or roving fabric. If the reinforcing fabric is Grade C finished a methacrylatochromic keying agent shall be stipulated.

3.1.3 When glass fibre reinforcement in the form of contour woven shapes is adopted the material shall be in accordance with specification D.T.D. 5559.

3.2 Resin

3.2.1 The resin system shall be to D.T.D. 5537 or D.T.D. 5549 and the type and class of resin stated (as appropriate to the service requirements for the components).

3.2.2 For radomes and dielectric window laminates Type E resin (controlled dielectric properties) shall be specified.

3.3 Sandwich Core Material

3.3.1 Sandwich core material of the expanded nitrile type shall be to D.T.D. 764.

3.3.2 Glass fibre honeycomb core material shall be an approved material and shall be described in respect of the cell size and glass fabric to be used.

**For ordering fabric whose construction is not listed in B.S.S. 3396, see Para. 2., Clause 3a, Part I of B.S.S. 3396.*

**To be issued later.*

4. Laminate Thickness and Glass Content

4.1 When a matched mould process is to be used the thickness of the laminate, together with the appropriate number of plies of the selected reinforcement, shall be stated.

4.2 When a single mould process is used the Table in Appendix I should be used to select the number of plies of chosen fabric in the light of the process adopted, and this information shown in combination with the target thickness on the drawing.

(Note: — The method of specifying the laminate proportions depends to some extent upon the method of manufacture. Where a matched mould process is used the thickness of the laminate may be predetermined to relatively close limits. When a single mould process is used the variation in laminate thickness will be much greater and will depend upon the effective consolidation achieved in the laminating process).

5. Fabric Orientation and Joints

5.1 The drawing shall indicate the general orientation of the fabric. For fabrics having widely different warp and weft strengths, precise instructions as to orientation shall be given.

5.2 Only butt joints should ordinarily be used in radome and dielectric window laminates; lap joints may, however, be used provided the electrical requirements are met. Either butt or lap joints may be called for in other structures.

5.2.1 Butt joints shall not be used with fewer than three plies of fabric and lap joints shall not have less than half an inch overlap.

5.2.2 Position of joints need not be shown on the drawing except when structural or electrical performance is likely to be affected.

5.3 Core Joints (Sandwich Construction)

5.3.1 Positions of core joints need not be shown on the drawing except where performance may be affected.

6. Curing Conditions

The curing conditions specified shall be chosen from those approved for the resin system, or shall have received separate D. Mat. and S. approval.

7. Surface Coating

7.1 Rain Erosion Protection‡

Rain erosion protection to the requirements of D.T.D. 926, or other approved scheme, shall be called for in the following areas:—

Maximum Speed in Flight Through Rain	*Area to which Erosion Protection is to be applied*
225-500 knots T.A.S.	Areas which present an angle of impact* in flight through rain of 30° or more.
Over 500 knots T.A.S.	Areas which present an angle of impact* in flight through rain of 15° or more.

For aircraft with design speeds in excess of Mach 1 reference shall be made to The Director, Royal Aircraft Establishment, (C.P.M. Dept.).

7.2 Other Surface Coatings

Where rain erosion protection is not required other approved surface coatings may be called for. The application instructions detailed in the approval of the coatings shall be specified.

SECTION III
MANUFACTURE

8. Storage and Working Conditions

8.1 Glass fabric shall be stored horizontally in rolls under conditions of less than 75% relative humidity.

8.2 Laying-up shall be done under conditions of less than 80% relative humidity for Grade S finished fabric, and less than 60% relative humidity for Grade C finished fabric. The fabric shall, immediately before lay-up, be in equilibrium with the conditions in the laminating shop, except where a pre-drying treatment is given immediately before use.

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‡*Attention is drawn to the fact that surface coatings, in particular the thicker anti-erosion types, can significantly affect the electrical behaviour of radome laminates. The original design of the radome must take into account therefore the 'electrical thickness' of any such coating.*

**Head-on-impact in flight through rain is considered as 90 degrees.*

9. Laminating

9.1 Release Agents

Release agents shall be readily and completely removable from the laminates, and where practicable shall be distinctively coloured. They shall be applied to the mould as an even film.

9.2 Resin Evaporation

All precautions shall be taken throughout the process to avoid loss of volatiles from the resin. In particular, resin containers shall be kept closed when not actually in use. Where a significant loss of styrene is found to be inevitable*, an addition of up to 5% styrene to offset losses shall be permitted.

9.3 Fabricating Procedures

The following manufacturing methods are recognised as being capable of producing parts to the standards of this specification when applied to the appropriate component by personnel experienced in the particular technique.: —

9.3.1 Contact laminating with cure at room or slightly elevated temperature.

9.3.2 "Contact" laminating using a transparent membrane cover and cure at room or elevated temperature.

9.3.3 Vacuum bag consolidation at low pressure difference.

9.3.4 Positive pressure consolidation using an autoclave.

9.3.5 Compression moulding using matched tools.

9.3.6 Resin injection into closed matched moulds.

Each of the above methods tends to produce laminates having characteristic differences and these features should be taken into account.

9.4 Joints in fabric

9.4.1 Fabric reinforcement shall be so laid that the joints are well staggered.

10. Sandwich Cores

10.1 Expanded hard rubber core

10.1.1 Unless the surface of the core material is to be removed the material shall be scrubbed with water to remove french chalk or other dusting material and dried at a temperature not‘ exceeding 112°C prior to forming.

10.1.2 Core boards shall be moulded to the required shape by a method which does not blister, crack, significantly alter the thickness of the boards or cause other visible damage.

10.1.3 Boards shall be carefully fitted, filling any gaps with slivers of core or other material approved for the purpose. Gaps shall not exceed the limit stated on the drawing.

10.1.4 The primer (if used) shall be applied and dried before laminating.

10.1.5 Sufficient time shall be allowed after cutting the core and before laminating to allow the escape of gases contained in the cells of the core.

10.2 Honeycomb Core

10.2.1 Where glass fabric honeycomb core is used it may be purchased (a) as flat cured board, (b) ready impregnated for curing to the requirements of the drawing, or, (c) in cases of greater curvature as unimpregnated material.

10.2.2 The core shall be assembled in such a way that adjacent pieces meet or intermesh.

10.2.3 The method of bonding cores to laminates shall be such as to produce small resin fillets at the joints with no large accretions.

11. Curing

11.1 Laminates using hot setting resin systems shall be cured in accordance with an approved curing cycle as stated on the drawing.

11.2 Laminates using cold setting resins shall be allowed to cure for at least 24 hours after the initial gel at room temperature, followed by post curing for 2 hours at 80°C (unless an alternative approved cycle is stated on the drawing).

**The major portion of the styrene loss takes place from the surface of the lay-up, especially with large components which take a long time to lay-up. The addition of extra styrene is allowed as a means of alleviating the problem.*

SECTION IV

INSPECTION

12. Process Control

12.1 Observations shall be made to ensure that the specified process is being followed.

12.2 Observations so made shall be recorded on the history sheet of each component. In particular, the actual mixing and curing conditions used shall be recorded.

13. Inspection of Completed Laminates

13.1 Visual Inspection

13.1.1 Laminates shall be inspected after completion of curing and removal of release agents but before any other treatment has been applied.

13.1.2 All components shall be free from surface undulations, creases or folds in the fabric and resin runs. There shall be no evidence of areas lacking resin, delamination between plies, or pockets of trapped air.

In the case of a component which is intrinsically difficult to fabricate, exemption may be given to the above requirements by agreement with the Design Authority and with the approval of D. Mat. and S.

13.1.3 Laminates shall exhibit a high degree of translucency but the presence in the laminate of small voids (bubbles) is admissible, provided that the size and incidence of these voids is such that when the component is viewed from a distance of 3 ft., under normal workshop conditions, the voids themselves are not visible as such nor do they significantly alter the translucency of the part.

13.1.4 For areas which in service are exposed to conditions under which rain erosion may occur, a greater freedom from voids is required. The areas required to conform to this higher standard shall be stipulated by the Design Authority, with the advice and approval of D. Mat. and S.

In such areas no voids shall be discernible when viewed by normal corrected vision from a distance of approximately 10 inches.

13.2 Inspection of Sandwich Structures

13.2.1 Expanded Hard Rubber Core Type

The bond between the skins and the core shall be substantially complete and free from air pockets over the whole surface. There shall be no obvious difference in quality (as judged by visual appearance) between the inner and outer skins, apart from any special requirements called for under Section 13.1.4.

13.2.2 Glass Fabric Honeycomb Core Type

Where skin laminates are bonded to the core there shall be small regular fillets of resin at the junction of the honeycomb and skin. Large accretions of resin are not acceptable. The above features should be readily discernible in the completed sandwich by virtue of the translucency of the skins.

13.3 State of Cure

13.3.1 The laminates shall be free from any surface tackiness, soft spots, or other indications of undercure.

13.3.2 The state of cure of the laminate shall be such that an average reading of at least 55 is obtained when use is made of a Barcol Impressor, as described in Appendix II.

APPENDIX I

DETAILS OF GLASS FABRICS TO BE USED FOR REINFORCEMENT

Range of Materials

Reinforcement fabric must be chosen from the list of materials detailed below.

Plain Weaves:

1. B.S.S.3396—P2/450/E — A 3 oz/sq yd plain weave material, stronger in warp than in weft, and made from 450's yarn.
2. B.S.S. 3396—P6/225/E — A 5½ oz/sq yd plain weave material of balanced strength made from 225's yarn.
3. B.S.S. 3396—P8/225 or 150/E — A 7 oz plain weave fabric made from 225's or 150's yarn and significantly stronger in weft than in warp.
4. B.S.S. 3396—P9/150/E — An 8½ oz fabric approximately balanced in strength.

Other Types:

5. B.S.S. 3396—S2/225/E — A 9 oz satin weave fabric giving excellent laminate mechanical properties, but inferior to the plain weaves in respect of control of thickness and resin content when used in contact laminating.
6. —T2/225/E — A twill weave equivalent of P6 plain. It shall be ordered in accordance with the second paragraph of Clause 3a of B.S.S. 3396 Part I.
7. Unidirectional Reinforcement
   B.S.S.3396— S1/225/450/E.
   — SI/150/450/E.

Fabric Thickness (Equivalent Ply Thickness in Laminate Form)

The following information is to be used as a guide in arriving at the correct number of plies of a given fabric to be used in making a laminate of pre-determined thickness.

The term "Free standing thickness" denotes the ply thickness obtained when a particular fabric is used to make a well-executed contact laminate. It will be noted that in a number of cases there is considerable difference between this "free standing thickness" and the nominal thickness quoted in the B.S. Specification for Glass Fabric. The figures for fabric ply thickness at 5, 15 and 30 inches of mercury effective pressure are included to provide information in respect of low pressure laminating operations.

It must be borne in mind, however, that in low pressure laminating techniques the pump circuit pressure reading does not necessarily indicate the conditions applying within the actual lay-up.

Effective Single Ply Thickness of Various Glass Fabrics When Laminated

Type of Glass Fibre Fabric	Nominal Thickness ins	"Contact Laminate" Thickness, ins	Thickness @ 5 in Hg	Thickness @ 15 in Hg	Thickness @ 30 in Hg
P2 Plain Weave (3 oz)	0.003	0.0045	0.004	0.0035	0.0035
P6 Plain Weave (5½ oz)	0.006	0.0075	0.007	0.0065	0.0065
P8 Plain Weave (7 oz)	0.009	0.012	0.011	0.010	0.0095
P9 Plain Weave (8½ oz)	0.011	0.013	0.011	0.010	0.0095
S2 Satin Weave (9 oz)	0.008	0.015	0.012	0.011	0.010
T2 Twill Weave (5½ oz)	——	0.009	0.0075	0.007	0.0065
Unidirectional	——	——	——	——	——

Laminate Thickness Tolerance (Contact and Vacuum Bag Processes)

With laminate nominal thickness based on the above figures it should be possible to produce components of average size and complexity to a thickness tolerance of minus 5% to plus 15 %. Any variation in thickness will result in a corresponding variation of resin contact.

Batch to batch variations in glass fabric weight (and hence thickness) will produce laminate thickness changes which will be over and above the general laminating tolerance referred to above.

APPENDIX II

TEST FOR CURE USING THE BARBER COLEMAN HARDNESS TESTER

Apparatus

The model adopted for the testing of reinforced plastics is type GYZJ 934-l.

Method of Test

Before use the instrument will be checked against the standard metal disc provided by the makers. When testing thin unsupported structures some form of rigid backing must be arranged immediately behind the test area. Valid readings cannot be obtained on material less than 1/32 in thick, even when supported. In use the instrument will be held firmly in the hand and carefully aligned so that the axis of the indentor is normal to the surface. With flat surfaces this requirement is automatically provided by the back support, but with curved surfaces some practice is needed before good alignment is maintained. Pressure will then be applied to bottom the head and after a pause of two seconds the reading will be taken. A minimum of ten such readings will be taken in at least each of two widely spaced areas of the laminate. The Barcol hardness will be reported as the average of the two (or more) groups.

Readings taken in the region of the trim line will be accepted provided the area under test is made up from the same fabric as the body of the laminate, and has a similar resin content, as indicated by the relative thickness.

Approved for issue

Director of Materials and Structures Research and Development.

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