AIRCRAFT TECHNICAL BOOK COMPANY

B1

AVIATION MAINTENANCE TECHNICIAN CERTIFICATION SERIES

MATERIALS AND HARDWARE

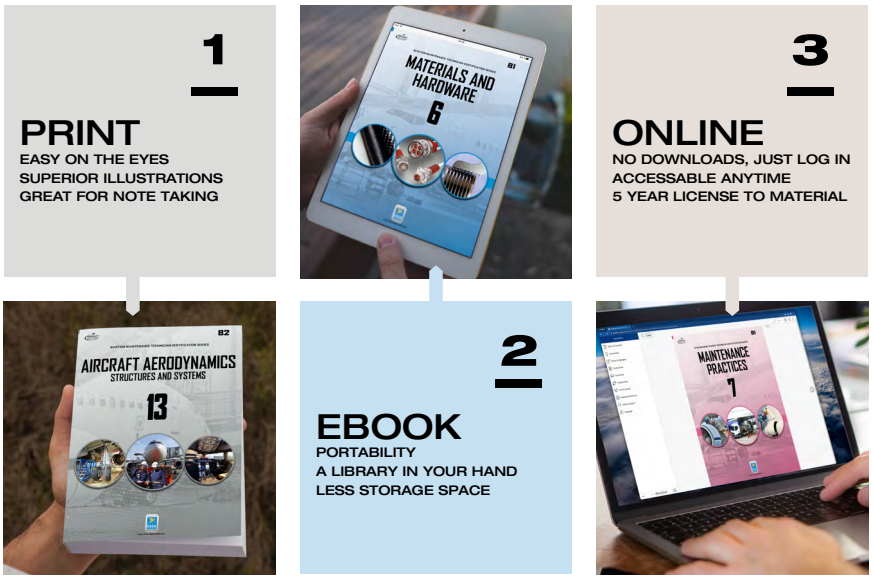
6

COMPLIANT WITH EASA PART 66/147

EASA 2023-989 COMPLIANT

The publishers of this Aviation Maintenance Technician Certification Series welcome you to the world of aviation maintenance. For additional educational tools created to prepare candidates for licensure, contact Aircraft Technical Book Company. We wish you good luck and success in your studies and in your aviation career!

EASA TEXTBOOKS ARE AVAILABLE IN PRINT, EBOOK DOWNLOAD, OR ONLINE READER



Special thanks to our instructors, contributors, and authors
Contributor - Mladen Hanževacki
Contributor - Dario Simunovic

Layout and Design by Michael Amrine

VERSION	EFFECTIVE DATE
005	2025.09

Copyright © 2013, 2025 — Aircraft Technical Book Company. All Rights Reserved.
No part of this publication may be reproduced, stored in a retrieval system, transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of the publisher.

To order books or for customer service, please call +1 (970) 726-5111, or visit us online at www.actechbooks.com

ISBN-13: 978-1964302324

REVISION LOG

Update notices for this book will be available online at www.actechbooks.com/revisions.html
If you would like to be notified when changes occur, please join our mailing list at www.actechbooks.com

VERSION	EFFECTIVE DATE	DESCRIPTION OF REVISION(S)
001	2013.01	Module creation and release.
002	2014.07	Format Updates
003	2018.07	Modified Submodule sequence in accordance to Appendix A. Added content in the following areas: 6.3 – Thixotropic agents; Wood preservation methods; Types of fabric defects. 6.4 – Stress corrosion; Exfoliated corrosion detection; Galvanic corrosion growth; Fretting corrosion. 6.5 – Screw threads; Dowels. 6.6 – Rigid fluid line sizes; Swaged fittings. 6.7 – Laws obeyed by springs. 6.8 – Bearing material and construction. 6.11 – Connector types, Identification codes, and ratings.
003.1	2023.04	Inclusion of Measurement Standards for clarification, page iv. Minor appearance and format updates.
004	2024.04	Regulatory update for EASA 2023-989 compliance.
005	2025.09	Rewrite of Submodule 5.4 and Submodule 11, with other corrections and clarifications.

MATERIALS AND HARDWARE

Revision Log . . . iii
Measurement Standards . . . iv
Basic Knowledge Requirements . . . v
Part 66 Basic Knowledge Requirements . . . vi
Table of Contents . . . ix

6.1 AIRCRAFT MATERIALS — FERROUS . . . 1.1
Section A . . . 1.1
Properties of Metals . . . 1.1
Hardness . . . 1.1
Strength . . . 1.1
Density . . . 1.1
Malleability . . . 1.1
Ductility . . . 1.1
Elasticity . . . 1.1
Toughness . . . 1.2
Brittleness . . . 1.2
Fusibility . . . 1.2
Conductivity . . . 1.2
Thermal Expansion . . . 1.2
Iron . . . 1.2
Steel and Steel Alloys . . . 1.2
Spark Testing . . . 1.2
Types of Alloyed Steel Carbon Steel . . . 1.3
Nickel Steel . . . 1.4
Chromium Steel . . . 1.4
Stainless Steel . . . 1.4
Chrome-Vanadium Steel . . . 1.4
Chromoly Steel . . . 1.4
Inconel . . . 1.4
Substitution of Aircraft Metals . . . 1.4
Metal Working Processes . . . 1.4
Hot Working . . . 1.4
Heat Treating . . . 1.6
Internal Structure of Metals . . . 1.6
Heat Treating Equipment . . . 1.6
Furnaces and Salt Baths . . . 1.7
Temperature Measurement and Control . . . 1.7
Heating . . . 1.7
Soaking . . . 1.8
Cooling . . . 1.8
Quenching Equipment . . . 1.10
Heat Treatment and Application of Alloy Steels . . . 1.10
Behavior of Steel During Heating and Cooling . . . 1.10
Hardening . . . 1.10
Hardening Precautions . . . 1.11
Tempering . . . 1.11
Annealing . . . 1.11
Normalizing . . . 1.11
Case Hardening . . . 1.12
Carburizing . . . 1.12
Nitriding . . . 1.12
Forging . . . 1.12
Casting . . . 1.12
Extruding . . . 1.13
Cold Working/Hardening . . . 1.13
Section B . . . 1.13
Hardness Testing . . . 1.13
Brinell Tester . . . 1.13
Rockwell Tester . . . 1.14
Other Testing . . . 1.15
Fatigue Strength Testing . . . 1.15
Impact Testing . . . 1.16
Electrochemical Testing of Stainless Versus Inconel . . . 1.16
Section C . . . 1.17
Defects . . . 1.17
Inspection Procedures . . . 1.17
Visual Inspection . . . 1.17
Surface Cracks . . . 1.17
Borescopes . . . 1.17
Non-Destructive Inspection (NDI) . . . 1.17
Corrosion Control . . . 1.18
General Repair Methods . . . 1.18
Submodule 1 Practice Questions . . . 1.19
Submodule 1 Practice Answers . . . 1.20

6.2 AIRCRAFT MATERIALS — NON-FERROUS . . . 2.1
Section A . . . 2.1
Characteristics, Properties and Identification of NonFerrous Materials . . . 2.1
Aluminum . . . 2.1
Wrought Aluminum . . . 2.2
Effect of Alloying Element . . . 2.3
Hardness Identification . . . 2.3
Magnesium . . . 2.3
Titanium . . . 2.4
Titanium Designations . . . 2.5
Corrosion Characteristics of Titanium . . . 2.5
Copper . . . 2.5
Nickel . . . 2.6
Monel . . . 2.6
K-Monel . . . 2.6
Inconel . . . 2.6
Substitution of Aircraft Metals . . . 2.6
Heat Treatment of Non-Ferrous Alloys . . . 2.7
Aluminum Alloys . . . 2.7
Alclad Aluminum . . . 2.7
Solution Heat Treatment . . . 2.7
Temperature . . . 2.7
Time at Temperature . . . 2.7
Quenching . . . 2.8
Cold Water Quenching . . . 2.8
Hot Water Quenching . . . 2.8
Spray Quenching . . . 2.8
Lag Between Soaking and Quenching . . . 2.8
Reheat Treatment . . . 2.8
Straightening After Solution Heat Treatment . . . 2.8
Precipitation Heat Treating . . . 2.8
Precipitation Practices . . . 2.9
Annealing of Aluminum Alloys . . . 2.9
Heat Treatment of Aluminum Rivets . . . 2.9

TABLE OF CONTENTS

Magnesium Alloys . . . 2.10
Solution Heat Treatment . . . 2.10
Precipitation Heat Treatment . . . 2.10
Titanium . . . 2.10
Stress Relieving . . . 2.10
Annealing of Titanium . . . 2.10
Thermal Hardening . . . 2.11
Case Hardening . . . 2.11
Casting . . . 2.11
Extruding . . . 2.11
Cold Working/Hardening . . . 2.11
Section B . . . 2.12
Hardness Testing . . . 2.12
Brinell Tester . . . 2.12
Rockwell Tester . . . 2.12
Barcol Tester . . . 2.13
Tensile, Fatigue and Impact Testing . . . 2.13
Section C . . . 2.13
Defects . . . 2.13
Inspection Procedures . . . 2.13
Visual Inspection . . . 2.13
Surface Cracks . . . 2.14
Borescopes . . . 2.14
Non-Destructive Inspection (NDI) . . . 2.14
Corrosion Control . . . 2.14
General Repair Methods . . . 2.14
Submodule 2 Practice Questions . . . 2.15
Submodule 2 Practice Answers . . . 2.16

6.3 AIRCRAFT MATERIALS — COMPOSITE AND NON-METALLIC . . . 3.1

6.3.1 Section A . . . 3.1
Characteristics, Properties and Identification . . . 3.1
Composite Materials . . . 3.1
Advantages/Disadvantages of Composites . . . 3.1
Composite Safety . . . 3.2
Fiber Reinforced Materials . . . 3.2
Laminated Structures . . . 3.2
Advanced Laminated Composite Materials . . . 3.2
Major Components of a Laminate . . . 3.3
Strength Characteristics . . . 3.3
Fiber . . . 3.3
Fiber Orientation . . . 3.3
Warp Clock . . . 3.3
Fiber Forms . . . 3.4
Roving . . . 3.4
Unidirectional (Tape) . . . 3.4
Bidirectional Fabric . . . 3.4
Non-woven (Knitted or Stitched) . . . 3.5
Types of Fiber . . . 3.5
Fiberglass . . . 3.5
Kevlar® . . . 3.6
Carbon/Graphite . . . 3.6
Boron . . . 3.6
Ceramic Fibers . . . 3.6
Lightning Protection Fibers . . . 3.6
Dry Fiber Material . . . 3.7
Thermosetting Resins . . . 3.7
Polyester Resins . . . 3.7
Vinyl Ester Resin . . . 3.7
Phenolic Resin . . . 3.7
Epoxy . . . 3.7
Polyimides . . . 3.7
Polybenzimidazoles . . . 3.8
Bismaleimides . . . 3.8
Thermoplastic Resins . . . 3.8
Semicrystalline Thermoplastics . . . 3.8
Amorphous Thermoplastics . . . 3.8
Polyether Ether Ketone . . . 3.8
Curing Stages of Resins . . . 3.8
Thixotropic Agents . . . 3.8
Pre-Impregnated Products (Prepregs) . . . 3.8
Adhesives . . . 3.9
Film Adhesives . . . 3.9
Paste Adhesives . . . 3.9
Foaming Adhesives . . . 3.10
Sandwich Structures . . . 3.10
Properties . . . 3.10
Facing Materials . . . 3.10
Core Materials . . . 3.11
Honeycomb . . . 3.11
Foam . . . 3.11
Balsa Wood . . . 3.12
Plastics . . . 3.12
Reinforced Plastic . . . 3.12
Transparent Plastics . . . 3.12
Optical Considerations . . . 3.13
Storage and Handling . . . 3.13
Forming Procedures and Techniques . . . 3.13
Heating . . . 3.13
Forms . . . 3.13
Forming Methods . . . 3.14
Simple Curve Forming . . . 3.14
Compound Curve Forming . . . 3.14
Stretch Forming . . . 3.14
Male and Female Die Forming . . . 3.14
Vacuum Forming Without Forms . . . 3.14
Vacuum Forming With a Female Form . . . 3.14
Sawing . . . 3.14
Drilling . . . 3.14
Cementing . . . 3.14
Application of Cement . . . 3.14
Repairs . . . 3.15
Cleaning . . . 3.15
Polishing . . . 3.15
Windshield Installation . . . 3.15
Installation Procedures . . . 3.16
Sealant and Bonding Agents . . . 3.16
One Part Sealants . . . 3.16
Two Part Sealants . . . 3.16
6.3.1 Section B . . . 3.17
Detection of Defects/Deterioration in Composite Materials . . . 3.17

Fiber Breakage . . . 3.17
Matrix Imperfections . . . 3.17
Delamination and Debonds . . . 3.18
Combinations of Damages . . . 3.18
Flawed Fastener Holes . . . 3.18
In-Service Defects . . . 3.18
Corrosion . . . 3.19
Non-Destructive Inspection of Composites . . . 3.19
Visual Inspection . . . 3.19
Audible Sonic Testing (Coin Tapping) . . . 3.19
Automated Tap Test . . . 3.20
Ultrasonic Inspection . . . 3.20
Through Transmission Ultrasonic Inspection . . . 3.21
Pulse Echo Ultrasonic Inspection . . . 3.21
Ultrasonic Bond Tester Inspection . . . 3.21
Phased Array Inspection . . . 3.21
Radiography . . . 3.21
Thermography . . . 3.22
Neutron Radiography . . . 3.22
Moisture Detector . . . 3.22
6.3.1 Section C . . . 3.22
Repair Procedures for Composite Materials and Structures . . . 3.22
Layup Materials and Tools . . . 3.22
Air Tools . . . 3.22
Caul Plate . . . 3.22
Support Tooling and Molds . . . 3.23
Vacuum Bag Materials . . . 3.23
Release Agents . . . 3.23
Bleeder Ply . . . 3.24
Peel Ply . . . 3.24
Layup Tapes . . . 3.24
Solid Release Film . . . 3.24
Breather Material . . . 3.24
Vacuum Bag . . . 3.24
Vacuum Equipment . . . 3.24
Vacuum Compaction Table . . . 3.25
Heat Sources . . . 3.25
Ovens . . . 3.25
Autoclave . . . 3.25
On Aircraft Heating . . . 3.25
Heat Bonder . . . 3.26
Heat Blanket . . . 3.26
Hot Air System . . . 3.26
Heat Press Forming . . . 3.26
Thermocouples . . . 3.27
Thermocouple Placement . . . 3.27
Thermal Survey of Repair Area . . . 3.27
Temperature Variations in Repair Zone . . . 3.27
Thermal Survey . . . 3.28
Solutions to Heat Sink Problems . . . 3.28
Types of Layups . . . 3.28
Wet Layups . . . 3.28
Prepregs . . . 3.28
Secondary Bonding . . . 3.29
Co-Bonding . . . 3.30
Wet Laminated Layup Techniques . . . 3.30
Bleedout Technique . . . 3.30
No Bleedout . . . 3.30
Ply Orientation Warp Clock . . . 3.31
Mixing Resins . . . 3.31
Saturation Techniques . . . 3.31
Impregnation With a Brush or Squeegee . . . 3.31
Vacuum Bagging Techniques . . . 3.31
Single Side Vacuum Bagging . . . 3.32
Envelope Bagging . . . 3.32
Impregnation Using a Vacuum Bag . . . 3.32
Alternate Pressure Application . . . 3.33
Shrink Tape . . . 3.33
C Clamps . . . 3.33
Shotbags and Weights . . . 3.33
Curing of Composite Materials . . . 3.33
Room Temperature Curing . . . 3.33
Elevated Temperature Curing . . . 3.33
Composite Honeycomb Sandwich Repairs . . . 3.34
Damage Classification . . . 3.35
Minor Core Damage (Filler and Potting Repairs) . . . 3.35
Damage Requiring Core Replacement and Repair to One or Both Face Plates . . . 3.35
Step 1: Inspect the Damage . . . 3.35
Step 2: Remove Water From Damaged Area . . . 3.35
Step 3: Remove the Damage . . . 3.35
Step 4: Prepare the Damaged Area . . . 3.35
Step 5: Installation of Honeycomb Core (Wet Layup) . . . 3.36
Step 6: Prepare and Install the Repair Plies . . . 3.37
Step 7: Vacuum Bag the Repair . . . 3.37
Step 8: Curing the Repair . . . 3.37
Step 9: Post Repair Inspection . . . 3.37
Bonded Flush Patch Repairs . . . 3.37
Step 1: Inspection and Mapping of Damage . . . 3.39
Step 2: Removal of Damaged Material . . . 3.39
Step 3: Surface Preparation . . . 3.39
Step 4: Molding . . . 3.39
Step 5: Laminating . . . 3.39
Step 6: Finishing . . . 3.39
Trailing Edge and Transition Area Patch Repairs . . . 3.39
Composite Patch Bonded to Aluminum Structure . . . 3.40
Fiberglass Molded Mat Repairs . . . 3.40
Radome Repairs . . . 3.40
External Bonded Patch Repairs . . . 3.41
External Bonded Repair With Prepreg Plies . . . 3.41
Step 1: Investigating and Mapping the Damage . . . 3.41
Step 2: Damage Removal . . . 3.41
Step 3: Layup of the Repair Plies . . . 3.41
Step 4: Vacuum Bagging . . . 3.41
Step 5: Curing the Repair . . . 3.41
Step 6: Applying Top Coat . . . 3.41
External Repair Using Wet Layup and Double Vacuum Debulk Method (DVD) . . . 3.41
Double Vacuum Debulk Principle . . . 3.41
Patch Installation on the Aircraft . . . 3.42
External Repair Using Precured Laminate Patches . . . 3.42
Step 3: A Precured Patch . . . 3.43

TABLE OF CONTENTS

Step 4: For a Precured Patch . . . 3.43
Bonded Versus Bolted Repairs. . . . 3.43
Bolted Repairs . . . 3.43
Bolted Repair Procedures . . . 3.44
Step 1: Inspection of the Damage . . . 3.44
Step 2: Removal of the Damage . . . 3.44
Step 3: Patch Preparation. . . . 3.44
Step 4: Hole Pattern Lay Out . . . 3.44
Step 5: Drilling and Reaming Holes in Patch and Parent Structure . . . 3.44
Step 6: Fastener Installation . . . 3.44
Step 7: Sealing of Fasteners and Patch . . . 3.44
Step 8: Finish Coat and Lightening Protection Mesh . . . 3.44
Fasteners Used With Composite Laminates . . . 3.44
Corrosion Precautions . . . 3.45
Fastener Materials . . . 3.45
Fastener Systems . . . 3.45
Adjustable Sustain Preload Fastening System (ASP) . . . 3.45
Hi-Lok® and Huck-Spin® Lockbolt Fasteners . . . 3.45
Eddie Bolt Fasteners . . . 3.46
Cherry's E-Z Buck (CSR90433) Hollow Rivet. . . . 3.46
Blind Fasteners. . . . 3.46
Blind Bolts . . . 3.47
Fiberlite . . . 3.47
Screws and Nutplates in Composite Structures . . . 3.47
Machining Processes and Equipment . . . 3.47
Drilling . . . 3.47
Equipment . . . 3.48
Processes and Precautions . . . 3.49
Countersinking . . . 3.49
Cutting Processes. . . . 3.50
Cutting Equipment . . . 3.50
Repair Safety . . . 3.50
Eye Protection . . . 3.51
Respiratory Protection. . . . 3.51
Downdraft Tables . . . 3.51
Skin Protection . . . 3.51
Fire Protection . . . 3.51
Section 6.3.2 . . . 3.51
Construction Methods of Wooden Airframe Structures . . . 3.51
Wood Aircraft Construction and Repairs. . . . 3.52
Characteristics, Properties and Types of Wood and Glue Used in Aeroplanes . . . 3.52
Wood . . . 3.52
Glues (Adhesives) . . . 3.52
Casein Glue . . . 3.52
Plastic Resin Glue . . . 3.52
Resorcinol . . . 3.52
Epoxy . . . 3.53
Preservation and Maintenance of Wooden Structures . . . 3.53
Wood Preservation . . . 3.53
Care and Maintenance of Wood Frame Structures . . . 3.53
Types of Defects in Wood Materials and Structures . . . 3.54
Defects Permitted . . . 3.54
Defects Not Permitted. . . . 3.54
Detection of Defects in Wooden Structures . . . 3.54
External and Internal Inspection. . . . 3.54
Glued Joint Inspection. . . . 3.55
Wood Condition . . . 3.56
Repair of Wooden Structures . . . 3.57
Gluing Procedures . . . 3.57
Preparation of Wood for Gluing . . . 3.57
Preparing Glues for Use. . . . 3.58
Applying the Glue/Adhesive . . . 3.58
Pressure on the Joint . . . 3.58
Testing Glued Joints . . . 3.58
Structural Repairs . . . 3.59
Wing Rib Repairs . . . 3.59
Bolt and Bushing Holes. . . . 3.60
Finishing Wood Structures . . . 3.60
Precautions. . . . 3.61
Finishing Exterior Surfaces. . . . 3.62
Finishing of End Grain Surfaces. . . . 3.62
Sealing of Bolt Holes . . . 3.62
Section 6.3.3 . . . 3.62
Fabric Covering . . . 3.62
General History. . . . 3.62
Characteristics, Properties and Types of Fabrics. . . . 3.63
Fabric Terms . . . 3.63
Approved Materials . . . 3.63
Fabric . . . 3.63
Anti-Chafe Tape . . . 3.63
Reinforcing Tape . . . 3.63
Rib Bracing . . . 3.63
Surface Tape. . . . 3.64
Rib Lacing Cord . . . 3.64
Sewing Thread . . . 3.64
Special Fabric Fasteners. . . . 3.64
Inspection Rings . . . 3.64
Primer . . . 3.65
Fabric Cement . . . 3.65
Fabric Sealer. . . . 3.65
Fillers . . . 3.65
Topcoats . . . 3.65
Types of Defects in Fabrics . . . 3.66
Excess Tension. . . . 3.66
Loose Fabric. . . . 3.66
Coating Cracks . . . 3.66
Deterioration . . . 3.66
Inspection Methods for Fabric . . . 3.67
Determining Fabric Condition; Repair or Recover? . . . 3.67
Fabric Strength . . . 3.67
How Fabric Breaking Strength is Determined . . . 3.67
Fabric Testing Devices. . . . 3.67
Repair of Fabric Covering . . . 3.68
Blanket Method Versus Envelope Method . . . 3.68
Preparation for Fabric Covering Work . . . 3.68
Removal of Old Fabric Coverings . . . 3.68
Preparation of the Airframe Before Covering. . . . 3.69
Attaching Polyester Fabric to the Airframe . . . 3.70
Fabric Cement . . . 3.70
Fabric Heat Shrinking . . . 3.71

Attaching Fabric to the Wing Ribs . . . 3.71
Rib Lacing . . . 3.71
Rings, Grommets, and Gussets . . . 3.73
Finishing Tapes . . . 3.74
Coating the Fabric . . . 3.74
Polyester Fabric Repairs . . . 3.75
Applicable Instructions . . . 3.75
Repair Considerations . . . 3.75
Submodule 3 Practice Questions . . . 3.77
Submodule 3 Practice Answers . . . 3.80

6.4 - CORROSION . . . 4.1
Section A . . . 4.1
Common Corrosive Agents . . . 4.1
Corrosion Formation . . . 4.2
Galvanic Action . . . 4.2
Microbiological Corrosion . . . 4.2
Stress Corrosion . . . 4.3
Section B . . . 4.3
General Surface Corrosion . . . 4.3
Pitting Corrosion . . . 4.3
Concentration Cell Corrosion . . . 4.4
Metal Ion Concentration Cells . . . 4.4
Oxygen Concentration Cells . . . 4.4
Active Passive Cells . . . 4.4
Filiform Corrosion . . . 4.5
Intergranular Corrosion . . . 4.6
Exfoliation Corrosion . . . 4.6
Galvanic Corrosion . . . 4.6
Stress Corrosion Cracking . . . 4.6
Fatigue Corrosion . . . 4.7
Fretting Corrosion . . . 4.8
Causes of Corrosion . . . 4.8
Material Types . . . 4.9
Aluminum and Aluminum Alloys . . . 4.9
Magnesium and Magnesium Alloys . . . 4.9
Ferrous Metals . . . 4.10
Noble Metals . . . 4.10
Chromium and Nickel Plated Parts . . . 4.10
Cadmium and Zinc Plated Parts . . . 4.10
Titanium and Titanium Alloys . . . 4.10
Susceptibility to Corrosion (Corrosion Prone Areas) . . . 4.10
Exhaust Trail Areas . . . 4.11
Battery Compartments and Battery Vent Openings . . . 4.11
Lavatories, Buffets and Galleys . . . 4.11
Bilge Areas . . . 4.11
Wheel Wells and Landing Gear . . . 4.11
External Skin Areas . . . 4.12
Water Entrapment Areas . . . 4.13
Engine Frontal Areas and Cooling Air Vents . . . 4.14
Electronic Package Compartments . . . 4.14
Miscellaneous Trouble Areas . . . 4.15
Seaplanes and Flooding . . . 4.16
Submodule 4 Practice Questions . . . 4.17
Submodule 4 Practice Answers . . . 4.18

6.5 FASTENERS . . . 5.1
6.5.1 Screw Threads . . . 5.2
Screw Principles . . . 5.2
The Inclined Plane . . . 5.2
Screw Nomenclature . . . 5.2
Bolt and Screw Terminology . . . 5.2
Screw Thread Terminology . . . 5.2
Thread Forms, Dimensions and Tolerances . . . 5.3
Coarse and Fine Pitch Threads . . . 5.3
Single and Multi Start Threads . . . 5.3
Screw Thread Profile . . . 5.3
International Thread System . . . 5.3
Unified Screw Thread . . . 5.3
Metric Screw Thread . . . 5.3
Choosing Threaded Fasteners . . . 5.3
Thread Tolerances . . . 5.4
Measuring Screw Threads . . . 5.4
Screw Thread Pitch . . . 5.4
Go-NoGo Gauges . . . 5.4
6.5.2 - Bolts, Studs And Screws . . . 5.4
Bolt Types: Specifications, Identification, and Marking of Aircraft Bolts, International Standards . . . 5.4
Aircraft Bolt Types . . . 5.4
Identification and Coding . . . 5.4
General Purpose Bolts . . . 5.4
Close Tolerance Bolts . . . 5.5
Internal Wrenching Bolts . . . 5.5
Special-Purpose Bolts . . . 5.5
Clevis Bolts . . . 5.6
Eyebolt . . . 5.6
Jo-Bolt . . . 5.6
Lockbolts . . . 5.6
Nuts: Self-locking, Anchor, Standard Types . . . 5.8
Aircraft Nuts . . . 5.8
Identification and Coding . . . 5.8
Non-Self-Locking Nuts . . . 5.8
Self-Locking Nuts . . . 5.9
Boots Self-Locking Nut . . . 5.9
Stainless Steel Self-Locking Nuts . . . 5.10
Elastic Stop Nuts . . . 5.10
Pal Nuts . . . 5.11
Sheet Spring Nuts . . . 5.11
Internal and External Wrenching Nuts . . . 5.11
Anchor Nuts . . . 5.11
Nutplates . . . 5.12
Sealing Nutplates . . . 5.12
Riveted and Rivetless Nutplates . . . 5.12
Rivnuts . . . 5.13
Machine Screws; Aircraft Specification . . . 5.14
Screws . . . 5.14
Identification/Coding for Screws . . . 5.14
Structural Screws . . . 5.14
Machine Screws . . . 5.14
Studs; Types and Uses . . . 5.14
Standard Studs . . . 5.15
Waisted Studs . . . 5.15

TABLE OF CONTENTS

Stepped Studs . . . 5.15
Shouldered Studs . . . 5.15
Self-Tapping Screws, Dowels . . . 5.15
Self-Tapping Screws . . . 5.15
Drive Screws . . . 5.16
Dowels . . . 5.16
Thread Repair Hardware . . . 5.16
Replacement Bushings . . . 5.16
Helicoils . . . 5.16
6.5.3 - Locking Devices . . . 5.17
Aircraft Washers . . . 5.17
Plain Washers . . . 5.17
Lockwashers . . . 5.17
Shakeproof Lockwashers . . . 5.18
Special Washers . . . 5.18
LockPlates . . . 5.18
Pins . . . 5.18
Cotter Pins . . . 5.18
Cotter Pin Hole Line Up . . . 5.18
Cotter Pin Safetying . . . 5.18
Roll Pins . . . 5.19
Quick Release (Captive) Fasteners . . . 5.19
Turnlock Fasteners . . . 5.19
Dzus Fasteners . . . 5.19
Camloc Fasteners . . . 5.19
Airloc Fasteners . . . 5.20
Keys . . . 5.20
Safety Wire Locking . . . 5.21
General Safety Wiring Rules . . . 5.21
Nuts, Bolts, and Screws . . . 5.21
Oil Caps, Drain Cocks, and Valves . . . 5.22
Electrical Connectors . . . 5.22
Turnbuckles . . . 5.22
6.5.4 Aircraft Rivets . . . 5.23
Standards and Specifications . . . 5.23
Solid Shank Rivets . . . 5.24
Solid Rivet Identification . . . 5.24
Rivet Corrosion . . . 5.25
Heat Treating Rivets . . . 5.25
Blind Rivets . . . 5.27
Friction Locked Blind Rivets . . . 5.27
Mechanical Lock Blind Rivets . . . 5.28
CherryMAX® Blind Rivets . . . 5.28
Removal of Mechanically Locked Blind Rivets . . . 5.28
Blind Rivet Specifications . . . 5.29
Rivet Material . . . 5.29
Diameters . . . 5.29
Blind Rivet Identification . . . 5.30
Nonstructural Blind Fasteners . . . 5.30
Pop rivets . . . 5.30
Pull Through Nutplate Blind Rivets . . . 5.31
Special Purpose Rivets and Fasteners . . . 5.31
Pin Fastening Systems (High Shear Fasteners) . . . 5.31
Installation of High Shear Fasteners . . . 5.31
Inspection of Pin Rivets . . . 5.31
Removal of Pin Rivets . . . 5.31
Hi-Lok Fastening System . . . 5.31
Hi-Tigue Fastening System . . . 5.32
Hi-Lite Fastening System . . . 5.32
Lockbolt Fastening Systems . . . 5.32
Installation Procedure . . . 5.33
Lockbolt Inspection . . . 5.33
Lockbolt Removal . . . 5.34
Blind Bolts . . . 5.34
Pull Type Blind Bolt . . . 5.34
Cherry Maxibolt Blind Bolt System . . . 5.34
Huck Blind Bolt System . . . 5.34
Drive Nut Type of Blind Bolt . . . 5.34
Installation procedure . . . 5.35
Tapered Shank Bolt . . . 5.35
Sleeve Bolts . . . 5.36
Rivet Nuts . . . 5.36
Rivnut Hole Preparation . . . 5.36
Deutsch Rivets . . . 5.36
Hole Repair Hardware . . . 5.36
Acres Fastener Sleeves . . . 5.37
Identification . . . 5.37
Hole Preparation . . . 5.37
Installation . . . 5.37
Sleeve Removal . . . 5.37
Submodule 5 Practice Questions . . . 5.41
Submodule 5 Practice Answers . . . 5.42

6.6 PIPES AND UNIONS . . . 6.1
Section A . . . 6.1
Rigid Fluid Lines . . . 6.1
Tubing Material . . . 6.1
Copper Tubing . . . 6.1
Aluminum Alloy Tubing . . . 6.1
Steel Tubing . . . 6.1
Titanium Tubing 3AL-2.5V . . . 6.1
Material Identification . . . 6.1
Tubing Sizes . . . 6.2
Flexible Hose Fluid Lines . . . 6.2
Rubber Hose Materials and Construction . . . 6.2
Buna-N . . . 6.2
Neoprene . . . 6.2
Butyl . . . 6.2
Low, Medium, and High Pressure Hoses . . . 6.2
Teflon™ Hose . . . 6.2
Hose Identification . . . 6.2
Size Designations . . . 6.3
Fluid Line Identification . . . 6.3
Section B . . . 6.3
Fluid Line End Fittings . . . 6.3
Universal Bulkhead Fittings . . . 6.4
AN Flared Fittings . . . 6.4
Flareless Fittings . . . 6.5
Swaged Fittings . . . 6.7
Cryofit™ Fittings . . . 6.8
Flexible Hose Fittings . . . 6.9
Submodule 6 Practice Questions . . . 6.11

Submodule 6 Practice Answers 6.12

6.7 SPRINGS 7.1
Types of Springs and Applications 7.1
Flat Springs 7.1
Leaf Springs 7.1
Spiral Springs 7.1
Helical Compression/Tension Springs 7.1
Helical Torsion Springs 7.1
Belleville (Cone Disc) Springs 7.2
Torsion Bar Springs 7.2
Spring Materials 7.2
Spring Dimensions 7.3
Spring Characteristics 7.3
Forces Exerted on, and Applied by Springs 7.3
Law Obeyed by Springs 7.3
Submodule 7 Practice Questions 7.5
Submodule 7 Practice Answers 7.6

6.8 BEARINGS 8.1
Bearing Loads 8.1
Bearings Material 8.1
Construction of Ball Bearings 8.1
Types of Bearings 8.2
Plain Bearings 8.2
Ball Bearings 8.2
Roller Bearings 8.2
Submodule 8 Practice Questions 8.3
Submodule 8 Practice Answers 8.4

6.9 TRANSMISSIONS 9.1
Driving and Driven Gears 9.1
Bevel Gears 9.1
Worm Gears 9.1
Helical Worm Gears 9.2
Planetary Gears 9.2
Rack and Pinion Gears 9.2
Gear Systems 9.2
Gear Terms 9.2
Backlash (or lash) 9.2
Idler Gear 9.3
Intermediate Gear 9.3
Compound Gear 9.3
Pinion Gear 9.3
Lay-shaft 9.3
Step-Up Drive 9.3
Step-Down Drive 9.3
Gear Ratio 9.3
Propeller Reduction Gearing 9.4
Gear Lash and Pattern 9.5
Non-gear Transmissions 9.6
Belts and Pulleys 9.6
Types of Belt Drives 9.6
Open Belt Drives 9.6
Crossed Belt Drives 9.6
Advantages and Disadvantages of Belt Drives 9.6
Chains and Sprocket 9.7
Advantages and Disadvantages of Chain Drives 9.7
Leaf Chains 9.8
Submodule 9 Practice Questions 9.9
Submodule 9 Practice Answers 9.10

6.10 CONTROL CABLES 10.1
Cable Control Systems 10.1
Types of Cables 10.1
Cable Construction 10.1
Cable Material 10.1
Cable Designations 10.1
Flexible Cables 10.1
Extra Flexible Cable 10.1
Non-Flexible Cables 10.2
End Fittings, Turnbuckles and Compensating Devices 10.2
Cable End Fittings 10.2
Cable Tension 10.2
Turnbuckles 10.2
Tensiometers 10.2
Compensating Devices 10.3
Pulleys and Cable System Components 10.3
Pulleys 10.3
Fairleads 10.4
Pressure Seals 10.4
Cable Connectors 10.4
Control Surface Travel Adjustment 10.4
Rigging Fixtures 10.4
Spring Back 10.4
Cable Drums 10.5
Aircraft Flexible Control Systems 10.5
Bowden Cables 10.5
Teleflex® Controls 10.5
Control Rods 10.6
Push Pull Rods 10.6
Torque Tubes 10.6
Submodule 10 Practice Questions 10.7
Submodule 10 Practice Answers 10.8

6.11 ELECTRICAL CABLES AND CONNECTORS 11.1
Cable (Wire) Types, Construction And Characteristics 11.1
Wire Types 11.1
Conductors 11.2
Plating 11.2
Insulation 11.2
Wire Shielding 11.2
Wire Substitutions 11.3
Areas Designated as Severe Wind And Moisture Problem (SWAMP) 11.3
Wire Size Selection 11.3
Current Carrying Capacity 11.6
Maximum Operating Temperature 11.7
Single Wire in Free Air 11.7
Wires in a Harness 11.7
Harness At Altitude 11.7
Aluminum Conductor Wire 11.7

TABLE OF CONTENTS

Computing Current Carrying Capacity 11.7
Example 1 . . . . . 11.7
Example 2 . . . . . 11.8
Allowable Voltage Drop 11.9
Electric Wire Chart Instructions. 11.9
Example A 11.10
Example B 11.10
Wire Identification. 11.10
Placement of Identification Markings 11.10
Types of Wire Markings 11.11
High Tension And Coaxial Cables 11.11
High Tension Cables 11.11
Coaxial Cables 11.12
Coaxial Cable Connectors 11.12
Crimping 11.12
Crimping Tools 11.12
Inspection And Testing Of Crimped Joints 11.12
Connectors 11.14
Types Of Connectors 11.14
Inline Junctions 11.15
Current And Voltage Rating 11.15
Coupling And Installation. 11.15
Connector Wiring 11.15
Wire Installation Into The Connector 11.16
Adjacent Locations 11.16
Sealing 11.16
Drainage. 11.16
Wire Support 11.16
Connector Identification 11.16
Standard 11.16
Type 11.16
Connector Class. 11.17
Class A 11.17
Class B 11.17
Class C 11.17
Class D 11.17
Class K 11.17
Shell Size 11.17
Contact Arrangement 11.17
Contact Style 11.17
Insert Rotation 11.17
Submodule 11 Practice Questions 11.19
Submodule 11 Practice Answers 11.20

Acronym Definitions A.1

Steel Number	Temperatures			Quenching Medium (n)	Tempering (drawing) Temperature for Tensile Strength (psi)				
	Normalizing Air Cool (°C)	Annealing (°C)	Hardening (°C)		100 000 (°C)	125 000 (°C)	150 000 (°C)	180 000 (°C)	200 000 (°C)
1020	900–955	870–925	855–910	Water	—	—	—	—	—
1022 (x1020)	900–955	870–925	855–910	Water	—	—	—	—	—
1025	870–925	870–900	855–910	Water	(a)	—	—	—	—
1035	855–900	855–885	830–870	Water	470	—	—	—	—
1045	845–870	845–870	800–845	Oil or Water	620	—	—	(n)	—
1095	800–845	790–815	775–815	Oil	(b)	—	595	455	400
2330	800–830	775–800	790–815	Oil or Water	595	510	423	—	—
3135	870–900	815–845	800–830	Oil	675	565	480	400	345
3140	870–900	815–845	800–830	Oil	720	580	495	413	370
4037	870	830–855	830–855	Oil or Water	665	595	525	—	—
4130 (x4130)	870–925	830–855	830–885	Oil (c)	(d)	565	480	370	300
4140	870–900	830–855	830–855	Oil	730	595	550	440	355
4150	845–870	800–830	845	Oil	—	690	635	565	510
4340 (x4340)	845–885	830–855	800–845	Oil	—	650	565	510	455
4640	910–925	830–855	815–845	Oil	—	650	565	400	330
6135	870–925	845–870	855–885	Oil	705	580	495	425	400
6150	870–900	830–855	845–885	Oil	(d)(e)	650	540	480	425
6195	870–900	830–855	815–845	Oil	(f)	—	—	—	—
NE8620	—	—	830–855	Oil	—	540	—	—	—
NE8630	900	830–855	830–855	Oil	—	605	525	415	355
NE8735	900	830–855	830–855	Oil	—	635	550	470	415
NE8740	885	815–845	815–845	Oil	—	650	580	495	455
30905	—	(g)(h)	(i)	—	—	—	—	—	—
51210	830–855	830–855	970–995(j)	Oil	650	595	(k)	400	—
51335	—	830–855	970–1 010	Oil	—	—	—	—	—
52100	885–925	760–790	830–845	Oil	(f)	—	—	—	—
Corrosion resisting (16–2)(1)	—	—	—	—	(m)	—	—	—	—
Silicon chromium (for springs)	—	—	925–940	Oil	—	—	—	—	—

NOTES:

(a) Draw at 620°C for tensile strength of 70 000 psi.

(b) For spring temper draw at 425-480°C. Rockwell hardness C-40-45.

(c) Bars or forgings may be quenched in water from 815–870°C.

(d) Air cooling from the normalizing temperature produces a tensile strength of approximately 90 000 psi.

(e) For spring temper draw at 455–510°C. Rockwell hardness C-40-45.

(f) Draw at 175–230°C to remove quenching strains. Rockwell hardness C-60-65.

(g) Anneal at 870–925°C to remove residual stresses due to welding or cold work. May be applied only to steel containing titanium or columbium.

(h) Anneal at 1 040–1 150°C to produce maximum softness and corrosion resistance. Cool in air or quench in water.

(i) Harden by cold work only.

(j) Lower side of range for sheet 0.06 inch and under. Middle of range for sheet and wire 0.125 inch. Upper side of range for forgings.

(k) Not recommended for intermediate tensile strengths because of low impact.

(l) AN-QQ-S-770—It is recommended that prior to tempering corrosion–resisting (16 Cr–2 Ni) steel be quenched in oil from a temperature of 1 025–1 040°C after a soaking period of 30 minutes at this temperature. To obtain a tensile strength at 115 000 psi the tempering temperature should be approximately 275°C. A holding time at these temperatures of about 2 hours is recommended. Tempering temperatures between 370°C and 595°C is not approved.

(m) Draw at approximately 425°C and cool in air for Rockwell hardness of C-50.

(n) Water used for quenching shall be within the temperature range of 25–60°C.

Figure 1-5. Heat treatment procedures for steels.

- 5xxx—magnesium
- 6xxx—magnesium and silicon
- 7xxx—zinc
- 8xxx—other elements

In the 2xxx through 8xxx alloy groups, the second digit in the alloy designation indicates alloy modifications. If the second digit is zero, it indicates the original alloy, while digits 1 through 9 indicate alloy modifications. The last two of the four digits in the designation identify the different alloys in the group. [**Figure 2-2**]

EFFECT OF ALLOYING ELEMENT

- 1000 series: Made of 99 percent aluminum or higher, excellent for its corrosion resistance, high thermal and electrical conductivity, low mechanical properties, and excellent workability. Iron and silicon are major impurities.
- 2000 series: Copper is the principal alloying element. Solution heat treatment, optimum properties equal to mild steel, poor corrosion resistance unclad. It is usually clad with 6000 or high purity alloy. Its best known alloy is 2024.
- 3000 series—Manganese is the principal alloying element of this group which is generally non-heat treatable. The percentage of manganese which will be alloy effective is 1.5 percent. The most popular is 3003, which is of moderate strength and has good working characteristics.
- 4000 series—Silicon is the principal alloying element of this group, and lowers melting temperature. Its primary use is in welding and brazing. When used in welding heat treatable alloys, this group will respond to a limited amount of heat treatment.
- 5000 series—Magnesium is the principal alloying element. It has good welding and corrosion resistant characteristics. High temperatures (over 65°C) or excessive cold working will increase susceptibility to corrosion.
- 6000 series: Silicon and magnesium form magnesium silicide which makes alloys heat treatable. It is of medium strength, good forming qualities, and has corrosion resistant characteristics.The most popular alloy of the series is 6061. When coupled with magnesium, it results in heat treatable alloys of very high strength. It usually has copper and chromium added.
- 7000 series: Zinc is the principal alloying element. The principal alloy of this group is 7075.

HARDNESS IDENTIFICATION

Where used, the temper designation follows the alloy designation and is separated from it by a dash: i.e., 7075- T6, 2024-T4, and so forth. The temper designation consists of a letter indicating the basic temper which may be more specifically defined by the addition of one or more digits. These designations are as follows:

- F - as fabricated
- O - annealed, recrystallized (wrought products only)
- H - strain hardened
- H1 (plus one or more digits) — strain hardened only
- H2 (plus one or more digits) — strain hardened and partially annealed
- H3 (plus one or more digits) — strain hardened and stabilized

The digit following the designations H1, H2, and H3 indicates the degree of strain hardening, number 8 representing the ultimate tensile strength equal to that achieved by a cold reduction of approximately 75 percent following a full anneal, 0 representing the annealed state.

MAGNESIUM

Magnesium, the world's lightest structural metal, is a silvery white material weighing only two-thirds as much as aluminum. Magnesium does not possess sufficient strength in its pure state

Percentage of Alloying Elements
(aluminum and normal impurities constitute remainder)

Alloy	Copper	Silicon	Manganese	Magnesium	Zinc	Nickel	Chromium	Lead	Bismuth
1100	—	—	—	—	—	—	—	—	—
3003	—	—	1.2	—	—	—	—	—	—
2011	5.5	—	—	—	—	—	—	0.5	0.5
2014	4.4	0.8	0.8	0.4	—	—	—	—	—
2017	4.0	—	0.5	0.5	—	—	—	—	—
2117	2.5	—	—	0.3	—	—	—	—	—
2018	4.0	—	—	0.5	—	2.0	—	—	—
2024	4.5	—	0.6	1.5	—	—	—	—	—
2025	4.5	0.8	0.8	—	—	—	—	—	—
4032	0.9	12.5	—	1.0	—	0.9	—	—	—
6151	—	1.0	—	0.6	—	—	0.25	—	—
5052	—	—	—	2.5	—	—	0.25	—	—
6053	—	0.7	—	1.3	—	—	0.25	—	—
6061	0.25	0.6	—	1.0	—	—	0.25	—	—
7075	1.6	—	—	2.5	5.6	—	0.3	—	—

Figure 2-2. Nominal composition of wrought aluminum alloys.

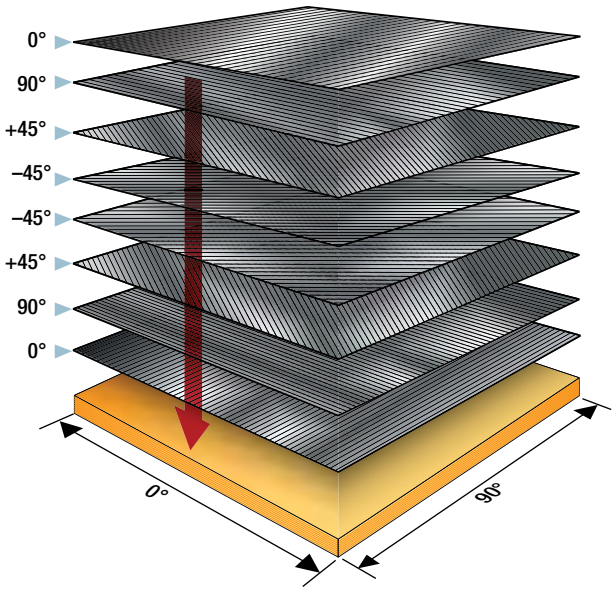


Figure 3-3. Quasi-isotropic material layup.

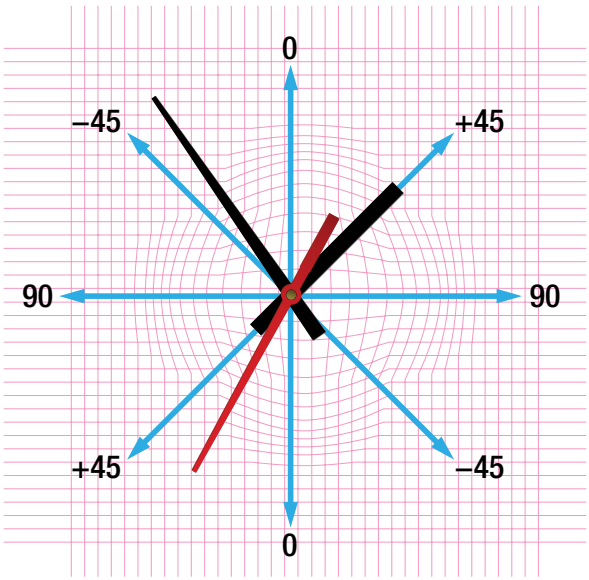


Figure 3-4. A warp clock.

FIBER FORMS

All product forms generally begin with spooled unidirectional raw fibers packaged as continuous strands. An individual fiber is called a filament. The word strand is also used to identify an individual glass fiber. Bundles of filaments are identified as tows, yarns, or rovings. Fiberglass yarns are twisted, while Kevlar® yarns are not. Tows and rovings do not have any twist. Most fibers are available as dry fiber that needs to be impregnated (impreg) with a resin before use or prepreg materials where the resin is already applied to the fiber.

ROVING

A roving is a single grouping of filament or fiber ends, such as 20-end or 60-end glass rovings. All filaments are in the same direction and they are not twisted. Carbon rovings are usually identified as 3K, 6K, or 12K rovings, K meaning 1 000 filaments. Most applications for roving products utilize mandrels for filament winding and then resin cure to final configuration.

UNIDIRECTIONAL (TAPE)

Unidirectional prepreg tapes have been the standard within the aerospace industry for many years, and the fiber is typically impregnated with thermosetting resins. The most common method of manufacture is to draw collimated raw (dry) strands into the impregnation machine where hot melted resins are combined with the strands using heat and pressure. Tape products have high strength in the fiber direction and virtually no strength across the fibers. The fibers are held in place by the resin. Tapes have a higher strength than woven fabrics. [**Figure 3-5**]

BIDIRECTIONAL FABRIC

Most fabric constructions offer more flexibility for layup of complex shapes than straight unidirectional tapes offer. Fabrics offer the option for resin impregnation either by solution or the hot melt process. Generally, fabrics used for structural applications use like fibers or strands of the same weight or yield in both the warp (longitudinal) and fill (transverse) directions. For aerospace structures, tightly woven fabrics are usually the choice to save weight, minimizing resin void size, and maintaining fiber orientation during the fabrication process.

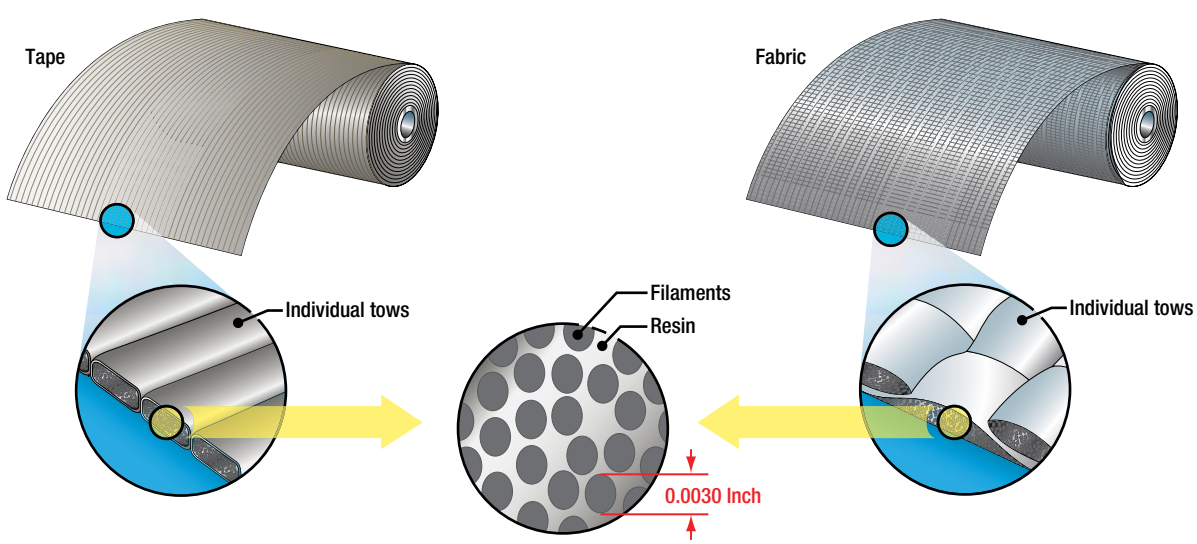


Figure 3-5. Tape and fabric products.

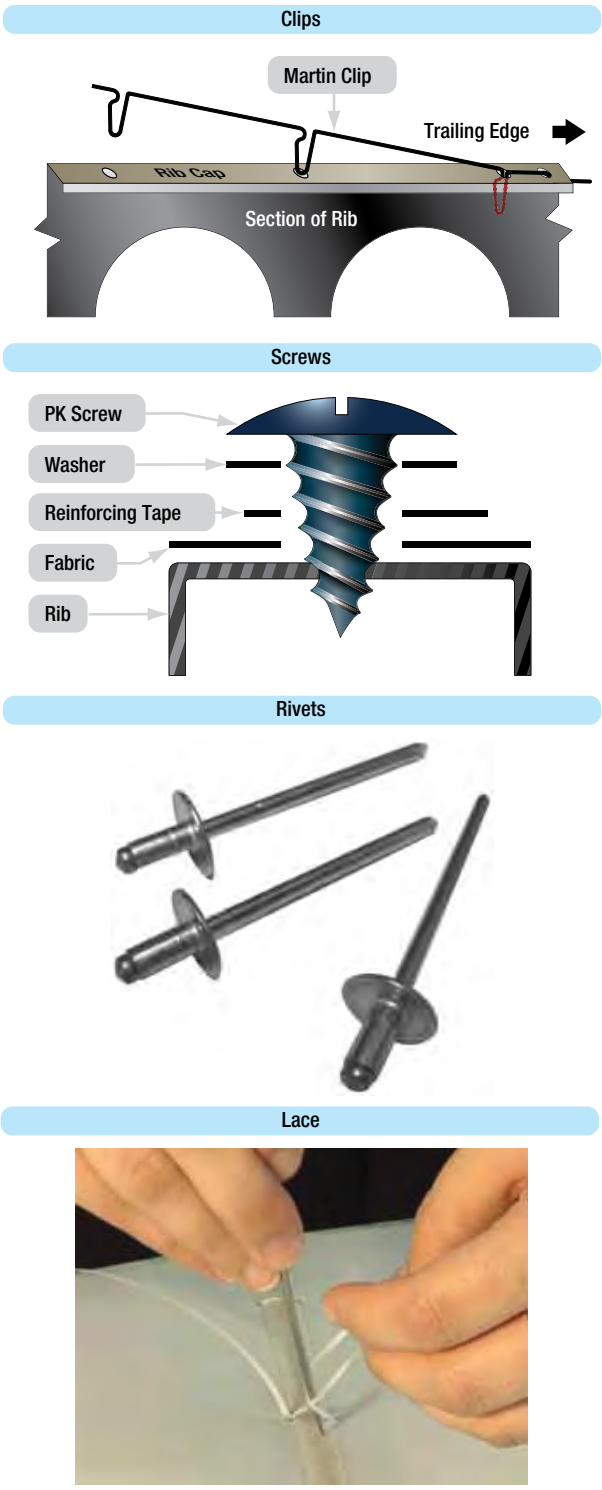


Figure 3-120. Clips, screws, rivets, or lace are used to attach the fabric to wing and empennage ribs.

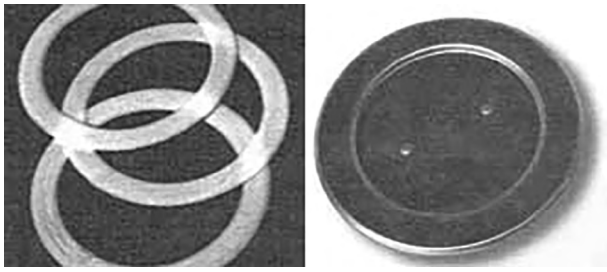


Figure 3-121. Inspection rings and an inspection cover.

The location of inspection rings are specified by the manufacturer. Additional rings are sometimes added to permit access to important areas that may not have been fitted originally with inspection access.

PRIMER

The airframe structure of a fabric covered aircraft must be cleaned, inspected, and prepared before the fabric covering process begins. The final preparation procedure involves priming the structure with a treatment that works with the adhesive and first coats of fabric sealant that are to be used. Each STC specifies which primers, or if a wood structure, which varnishes are suitable. Most often, two part epoxy primers are used on metal structure and two part epoxy varnishes are used on wood structure.

FABRIC CEMENT

Modern fabric covering systems utilize special fabric cement to attach the fabric to the airframe. There are various types of cement. In addition to good adhesion qualities, flexibility, and long life, fabric cements must be compatible with the primer and the fabric sealer that are applied before and after the cement.

FABRIC SEALER

Fabric sealer surrounds the fibers in the fabric with a protective coating to provide adhesion and keep out dirt and moisture. The sealer is the first coat applied to the polyester fabric after it is attached to the airframe and heat shrunk to fit snugly.

FILLERS

After the fabric sealer is applied, a filler is used. It is sprayed on in a number of cross coats as required by the manufacturer or the STC. The filler contains solids or chemicals that are included to block UV light from reaching the fabric. Proper fill coating is critical because UV light is the single most destructive element that causes polyester fabric to deteriorate.

TOPCOATS

Once the aircraft fabric has been installed, sealed, and fill coat protected, finishing or topcoats are applied to give the aircraft its final appearance. It is important to use the topcoat products and procedures specified in the applicable STC to complete an airworthy fabric recovering job.

The use of various additives is common at different stages. The following is a short list of products that facilitate the proper application of topcoats. Note again that only products approved under a particular STC can be used.

- A catalysts accelerates a chemical reaction. Catalysts are specifically designed for each product with which they are mixed and are common with epoxies and polyurethanes.
- A thinner is a solvent added to a product to give it the proper consistency for application.
- A retarder is added to slow drying time. Used mostly in topcoats, a retarder allow more time for a sprayed coating to flow, resulting in a deeper glossier finish. It is used when the working temperature is elevated slightly above the ideal temperature for a product. It also can be used to prevent blushing when high humidity conditions exist.
- Accelerators contains solvents that speed up the drying

bolt to break off when the sleeve is properly seated. These types of bolts are available in many different head styles, including protruding head, 100° flush head, 130° flush head, and hex head.

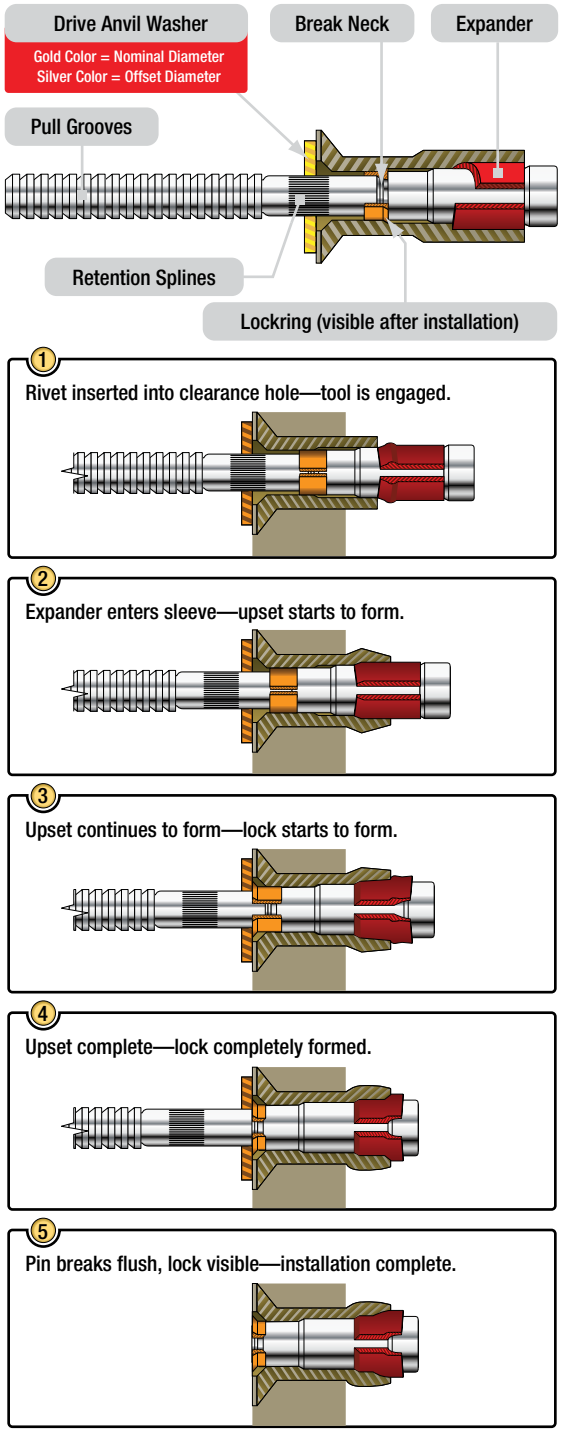


Figure 5-61. Huck Blind Bolt system.

Figure 5-62. A Visu-Lok type of drive nut type blind bolt.

Use the grip gauge available for the type of fastener and select the bolt grip after careful determination of the material thickness. The grip of the bolt is critical for correct installation. [**Figure 5-63**]

INSTALLATION PROCEDURE

1. Install the fastener into the hole, and place the installation tooling over the screw (stem) and nut.
2. Apply torque to the screw with the installation tool while keeping the drive nut stationary. The screw continues to advance through the nut body causing the sleeve to be drawn up over the tapered nose of the nut. When the sleeve forms tightly against the blind side of the structure, the screw fractures in the break groove. The stem of Jo-bolts, Visu-Lok, and Composi-Lok II fasteners does not break off flush with the head. A screw break-off shaver tool must be used if a flush installation is required. The stem of the Composi-Lok III and OSI bolt break off flush.

TAPERED SHANK BOLT

Tapered shank bolts, such as the Taper-Lok, are lightweight, high strength shear or tension bolts. This bolt has a tapered shank designed to provide an interference fit upon installation. Tapered shank bolts can be identified by a round head (rather than a screwdriver slot or wrench flats) and a threaded shank. The Taper-Lok is comprised of a tapered, conical shank fastener, installed into a precision tapered hole. The use of tapered shank bolts is limited to special applications such as high stress areas of fuel tanks. It is important that a tapered bolt not be substituted for any other type of fastener in repairs. It is equally as important not to substitute any other type of fastener for a tapered bolt.

Tapered shank bolts look similar to Hi-Lok bolts after installation, but the tapered shank bolts do not have the hex recess at the threaded end of the bolt. Tapered shank bolts are installed in precision reamed holes, with a controlled interference fit. The interference fit compresses the material around the hole that results in excellent load transfer, fatigue resistance, and sealing. The collar used with the tapered shank bolts has a captive washer, and so no extra washers are required. New tapered shank bolt installation or rework of tapered shank bolt holes needs to be accomplished by trained personnel. Properly installed, these bolts become tightly wedged and do not turn while torque is applied to the nut.

Figure 5-63. A Jo-Bolt and Visu-Lok pneumatic installation tool.