Inspections are visual examinations and manual checks to determine the condition of an aircraft or component. An aircraft inspection can range from a casual walk-around to a detailed inspection involving complete disassembly and the use of complex inspection aids.

An inspection system consists of several processes, including reports made by mechanics or the pilot or crew flying an aircraft and regularly scheduled inspections of an aircraft. An inspection system is designed to maintain an aircraft in the best possible condition. Thorough and repeated inspections must be considered the backbone of a good maintenance program. Irregular and haphazard inspection will invariably result in gradual and certain deterioration of an aircraft. The time spent in repairing an abused aircraft often totals far more than any time saved in hurrying through routine inspections and maintenance.

It has been proven that regularly scheduled inspections and preventive maintenance assure airworthiness. Operating failures and malfunctions of equipment are appreciably reduced if excessive wear or minor defects are detected and corrected early. The importance of inspections and the proper use of records concerning these inspections cannot be overemphasized.

Airframe and engine inspections may range from preflight inspections to detailed inspections. The time intervals for the inspection periods vary with the models of aircraft involved and the types of operations being conducted. The airframe and engine manufacturer's instructions should be consulted when establishing inspection intervals.

Aircraft may be inspected using flight hours as a basis for scheduling, or on a calendar inspection system. Under the calendar inspection system, the appropriate inspection is performed on the expiration of a specified number of calendar weeks. The calendar inspection system is an efficient system from a maintenance management standpoint. Scheduled replacement of components with stated hourly operating limitations is normally accomplished during the calendar inspection falling nearest the hourly limitation.

In some instances, a flight hour limitation is established to limit the number of hours that may be flown during the calendar interval.

Aircraft operating under the flight hour system are inspected when a specified number of flight hours are accumulated. Components with stated hourly operating limitations are normally replaced during the inspection that falls nearest the hourly limitation.

Basic Inspection Techniques/Practices

Before starting an inspection, be certain all plates, access doors, fairings, and cowling have been opened or removed and the structure cleaned. When opening inspection plates and cowling and before cleaning the area, take note of any oil or other evidence of fluid leakage.

Preparation

In order to conduct a thorough inspection, a great deal of paperwork and/or reference information must be accessed and studied before actually proceeding to the aircraft to conduct the inspection. The aircraft logbooks must be reviewed to provide background information and a maintenance history of the particular aircraft. The appropriate checklist or checklists must be utilized to ensure that no items will be forgotten or overlooked during the inspection. Also, many additional publications must be available, either in hard copy or in electronic format to assist in the inspections. These additional publications may include information provided by the aircraft and engine manufacturers, appliance manufacturers, parts venders, and the Federal Aviation Administration (FAA).

Aircraft Logs

"Aircraft logs," as used in this handbook, is an inclusive term which applies to the aircraft logbook and all supplemental records concerned with the aircraft. They may come in a variety of formats. For a small aircraft, the log may indeed be a small 5" × 8" logbook. For larger aircraft, the logbooks are often larger, in the form of a three-ring binder. Aircraft that have been in service for a long time are likely to have several logbooks.

The aircraft logbook is the record in which all data concerning the aircraft is recorded. Information gathered in this log is used to determine the aircraft condition, date of inspections, time on airframe, engines and propellers. It reflects a history of all significant events occurring to the aircraft, its components, and accessories, and provides a place for indicating compliance with FAA airworthiness directives or manufacturers' service bulletins. The more comprehensive the logbook, the easier it is to understand the aircraft's maintenance history.

When the inspections are completed, appropriate entries must be made in the aircraft logbook certifying that the aircraft is in an airworthy condition and may be returned to service. When making logbook entries, exercise special care to ensure that the entry can be clearly understood by anyone having a need to read it in the future. Also, if making a hand-written entry, use good penmanship and write legibly. To some degree, the organization, comprehensiveness, and appearance of the aircraft logbooks have an impact on the value of the aircraft. High quality logbooks can mean a higher value for the aircraft.

Checklists

Always use a checklist when performing an inspection. The checklist may be of your own design, one provided by the manufacturer of the equipment being inspected, or one obtained from some other source. The checklist should include the following:

1. Fuselage and hull group.
   a. Fabric and skin — for deterioration, distortion, other evidence of failure, and defective or insecure attachment of fittings.
   b. Systems and components — for proper installation, apparent defects, and satisfactory operation.
   c. Envelope gas bags, ballast tanks, and related parts — for condition.
2. Cabin and cockpit group.
   a. Generally — for cleanliness and loose equipment that should be secured.
   b. Seats and safety belts — for condition and security.
   c. Windows and windshields — for deterioration and breakage.
   d. Instruments — for condition, mounting, marking, and (where practicable) for proper operation.
   e. Flight and engine controls — for proper installation and operation.
   f. Batteries — for proper installation and charge.
   g. All systems — for proper installation, general condition, apparent defects, and security of attachment.
3. Engine and nacelle group.
   a. Engine section — for visual evidence of excessive oil, fuel, or hydraulic leaks, and sources of such leaks.
   b. Studs and nuts — for proper torquing and obvious defects.
   c. Internal engine — for cylinder compression and for metal particles or foreign matter on screens and sump drain plugs. If cylinder compression is weak, check for improper internal condition and improper internal tolerances.
   d. Engine mount — for cracks, looseness of mounting, and looseness of engine to mount.
   e. Flexible vibration dampeners — for condition and deterioration.
   f. Engine controls — for defects, proper travel, and proper safetying.
   g. Lines, hoses, and clamps — for leaks, condition, and looseness.
   h. Exhaust stacks — for cracks, defects, and proper attachment.
   i. Accessories — for apparent defects in security of mounting.
   j. All systems — for proper installation, general condition defects, and secure attachment.
   k. Cowling — for cracks and defects.
   l. Ground runup and functional check — check all powerplant controls and systems for correct response, all instruments for proper operation and indication.

4. Landing gear group.
   a. All units—for condition and security of attachment.
   b. Shock absorbing devices—for proper oleo fluid level.
   c. Linkage, trusses, and members—for undue or excessive wear, fatigue, and distortion.
   d. Retracting and locking mechanism—for proper operation.
   e. Hydraulic lines—for leakage.
   f. Electrical system—for chafing and proper operation of switches.
   g. Wheels—for cracks, defects, and condition of bearings.
   h. Tires—for wear and cuts.
   i. Brakes—for proper adjustment.
   j. Floats and skis—for security of attachment and obvious defects.
5. Wing and center section.
   a. All components—for condition and security.
   b. Fabric and skin—for deterioration, distortion, other evidence of failure, and security of attachment.
   c. Internal structure (spars, ribs compression members)—for cracks, bends, and security.
   d. Movable surfaces—for damage or obvious defects, unsatisfactory fabric or skin attachment and proper travel.
   e. Control mechanism—for freedom of movement, alignment, and security.
   f. Control cables—for proper tension, fraying, wear and proper routing through fairleads and pulleys.
6. Empennage group.
   a. Fixed surfaces—for damage or obvious defects, loose fasteners, and security of attachment.
   b. Movable control surfaces—for damage or obvious defects, loose fasteners, loose fabric, or skin distortion.
   c. Fabric or skin—for abrasion, tears, cuts or defects, distortion, and deterioration.
7. Propeller group.
   a. Propeller assembly—for cracks, nicks, bends, and oil leakage.
   b. Bolts—for proper torquing and safetying.
   c. Anti-icing devices—for proper operation and obvious defects.
   d. Control mechanisms—for proper operation, secure mounting, and travel.
8. Communication and navigation group.
   a. Radio and electronic equipment—for proper installation and secure mounting.
   b. Wiring and conduits—for proper routing, secure mounting, and obvious defects.
   c. Bonding and shielding—for proper installation and condition.
   d. Antennas—for condition, secure mounting, and proper operation.
9. Miscellaneous.
   a. Emergency and first aid equipment—for general condition and proper stowage.
   b. Parachutes, life rafts, flares, and so forth—inspect in accordance with the manufacturer's recommendations.
   c. Autopilot system—for general condition, security of attachment, and proper operation.

Publications

Aeronautical publications are the sources of information for guiding aviation mechanics in the operation and maintenance of aircraft and related equipment. The proper use of these publications will greatly aid in the efficient operation and maintenance of all aircraft. These include manufacturers' service bulletins, manuals, and catalogs; FAA regulations; airworthiness directives; advisory circulars; and aircraft, engine and propeller specifications.

Manufacturers' Service Bulletins/Instructions

Service bulletins or service instructions are two of several types of publications issued by airframe, engine, and component manufacturers.

The bulletins may include: (1) purpose for issuing the publication, (2) name of the applicable airframe, engine, or component, (3) detailed instructions for service, adjustment, modification or inspection, and source of parts, if required and (4) estimated number of manhours required to accomplish the job.

Maintenance Manual

The manufacturer's aircraft maintenance manual contains complete instructions for maintenance of all systems and components installed in the aircraft. It contains information for the mechanic who normally works on components, assemblies, and systems while they are installed in the aircraft, but not for the overhaul mechanic. A typical aircraft maintenance manual contains:

- A description of the systems (i.e., electrical, hydraulic, fuel, control)
- Lubrication instructions setting forth the frequency and the lubricants and fluids which are to be used in the various systems,
- Pressures and electrical loads applicable to the various systems,
- Tolerances and adjustments necessary to proper functioning of the airplane,
- Methods of leveling, raising, and towing,
- Methods of balancing control surfaces,
- Identification of primary and secondary structures,
- Frequency and extent of inspections necessary to the proper operation of the airplane,
- Special repair methods applicable to the airplane,
- Special inspection techniques requiring x-ray, ultrasonic, or magnetic particle inspection, and
- A list of special tools.

Overhaul Manual

The manufacturer's overhaul manual contains brief descriptive information and detailed step by step instructions covering work normally performed on a unit that has been removed from the aircraft. Simple, inexpensive items, such as switches and relays on which overhaul is uneconomical, are not covered in the overhaul manual.

Structural Repair Manual

This manual contains the manufacturer's information and specific instructions for repairing primary and secondary structures. Typical skin, frame, rib, and stringer repairs are covered in this manual. Also included are material and fastener substitutions and special repair techniques.

Illustrated Parts Catalog

This catalog presents component breakdowns of structure and equipment in disassembly sequence. Also included are exploded views or cutaway illustrations for all parts and equipment manufactured by the aircraft manufacturer.

Code of Federal Regulations (CFRs)

The CFRs were established by law to provide for the safe and orderly conduct of flight operations and to prescribe airmen privileges and limitations. A knowledge of the CFRs is necessary during the performance of maintenance, since all work done on aircraft must comply with CFR provisions.

Airworthiness Directives

A primary safety function of the FAA is to require correction of unsafe conditions found in an aircraft, aircraft engine, propeller, or appliance when such conditions exist and are likely to exist or develop in other products of the same design. The unsafe condition may exist because of a design defect, maintenance, or other causes. Title 14 of the Code of Federal Regulations (14 CFR) part 39, Airworthiness Directives, defines the authority and responsibility of the Administrator for requiring the necessary corrective action. The Airworthiness Directives (ADs) are published to notify aircraft owners and other interested persons of unsafe conditions and to prescribe the conditions under which the product may continue to be operated.

Airworthiness Directives are Federal Aviation Regulations and must be complied with unless specific exemption is granted.

Airworthiness Directives may be divided into two categories: (1) those of an emergency nature requiring immediate compliance upon receipt and (2) those of a less urgent nature requiring compliance within a relatively longer period of time. Also, ADs may be a one-time compliance item or a recurring item that requires future inspection on an hourly basis (accrued flight time since last compliance) or a calendar time basis.

The contents of ADs include the aircraft, engine, propeller, or appliance model and serial numbers affected. Also included are the compliance time or period, a description of the difficulty experienced, and the necessary corrective action.

Type Certificate Data Sheets

The type certificate data sheet (TCDS) describes the type design and sets forth the limitations prescribed by the applicable CFR part. It also includes any other limitations and information found necessary for type certification of a particular model aircraft.

Type certificate data sheets are numbered in the upper right-hand corner of each page. This number is the same as the type certificate number. The name of the type certificate holder, together with all of the approved models, appears immediately below the type certificate number. The issue date completes this group. This information is contained within a bordered text box to set it off.

The data sheet is separated into one or more sections. Each section is identified by a Roman numeral followed by the model designation of the aircraft to which the section pertains. The category or categories in which the aircraft can be certificated are shown in parentheses following the model number. Also included is the approval date shown on the type certificate.

The data sheet contains information regarding:

1. Model designation of all engines for which the aircraft manufacturer obtained approval for use with this model aircraft.
2. Minimum fuel grade to be used.
3. Maximum continuous and takeoff ratings of the approved engines, including manifold pressure (when used), rpm, and horsepower (hp).
4. Name of the manufacturer and model designation for each propeller for which the aircraft manufacturer obtained approval will be shown together with the propeller limits and any operating restrictions peculiar to the propeller or propeller engine combination.
5. Airspeed limits in both mph and knots.
6. Center of gravity range for the extreme loading conditions of the aircraft is given in inches from the datum. The range may also be stated in percent of MAC (Mean Aerodynamic Chord) for transport category aircraft.
7. Empty weight center of gravity (CG) range (when established) will be given as fore and aft limits in inches from the datum. If no range exists, the word "none" will be shown following the heading on the data sheet.
8. Location of the datum.
9. Means provided for leveling the aircraft.
10. All pertinent maximum weights.
11. Number of seats and their moment arms.
12. Oil and fuel capacity.
13. Control surface movements.
14. Required equipment.
15. Additional or special equipment found necessary for certification.
16. Information concerning required placards.

It is not within the scope of this handbook to list all the items that can be shown on the type certificate data sheets. Those items listed above serve only to acquaint aviation mechanics with the type of information generally included on the data sheets. Type certificate data sheets may be many pages in length. Figure 8-1 shows a typical TCDS.

When conducting a required or routine inspection, it is necessary to ensure that the aircraft and all the major items on it are as defined in the type certificate data sheets. This is called a conformity check, and verifies that the aircraft conforms to the specifications of the aircraft as it was originally certified. Sometimes alterations are made that are not specified or authorized in the TCDS. When that condition exists, a supplemental type certificate (STC) will be issued. STCs are considered a part of the permanent records of an aircraft, and should be maintained as part of that aircraft's logs.

Routine/Required Inspections

For the purpose of determining their overall condition, 14 CFR provides for the inspection of all civil aircraft at specific intervals, depending generally upon the type of operations in which they are engaged. The pilot in command of a civil aircraft is responsible for determining whether that aircraft is in condition for safe flight. Therefore, the aircraft must be inspected before each flight. More detailed inspections must be conducted by aviation maintenance technicians at least once each 12 calendar months, while inspection is required for others after each 100 hours of flight. In other instances, an aircraft may be inspected in accordance with a system set up to provide for total inspection of the aircraft over a calendar or flight time period.

To determine the specific inspection requirements and rules for the performance of inspections, refer to the CFR, which prescribes the requirements for the inspection and maintenance of aircraft in various types of operations.

Preflight/Postflight Inspections

Pilots are required to follow a checklist contained within the Pilot's Operating Handbook (POH) when operating aircraft. The first section of a checklist includes a section entitled Preflight Inspection. The preflight inspection checklist includes a "walk-around" section listing items that the pilot is to visually check for general condition as he or she walks around the airplane. Also, the pilot must ensure that fuel, oil and other items required for flight are at the proper levels

(Continued on page 8-12)

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

A25CE
Revision 11
CESSNA
404
406
June 15, 1995

TYPE CERTIFICATE DATA SHEET NO. A25CE

This data sheet which is part of Type Certificate No. A25CE prescribes conditions and limitations under which the product for which the type certificate was issued meets the airworthiness requirements of the Federal Aviation Regulations.

Type Certificate Holder — Cessna Aircraft Company
P. O. Box 7704
Wichita, Kansas 67277

I - Model 404, Titan, (Normal Category), Approved July 21, 1976

Engines — Two Teledyne Continental GTSIO-520-M
Reduction gear ratio .667:1

Fuel — 100/130 or 100 low-lead minimum grade aviation gasoline
See NOTE 3 for optional anti-icing additive

Engine Limits — For all operations, 2235 propeller r.p.m. (375 hp.)
40.0 in. Hg. mp. up to critical altitude of 16,000 feet in standard atmosphere. Above 16,000 feet the following maximum mp. applies for maximum r.p.m.

Altitude (ft.)	Max. Allowable Mp. (in. Hg)
16,000	40.0
18,000	37.5
20,000	35.0
22,000	32.0
24,000	29.2
26,000	26.0
28,000	23.0
30,000	20.0

Propeller and Propeller Limits — Two McCauley full-feathering three-bladed propeller installations

(a) McCauley hub 3FF32C501 with 90UMB-0 blades
Diameter: not over 90.0 in., not under 88.5 in.
No further reduction permitted
Pitch settings at 30.0 in. sta.:
low 16.6°, ±0.2°, feathering 84.6°, ±0.3°

S/N 404-0001 through 404-0600

(b) Hydraulic governor McCauley DCF290D2/T6, DCFU290D2/T6, DCFS290D2/T6, DCFUS290D2/T6, DCF290D7/T6, DCFU290D7/T6 or DCFU290D13/T6, DCFS290D7/T6, DCFUS290D7/T6 or DCFUS290D13/T6

S/N 404-0601 and up

(b) Hydraulic governor McCauley DCF290D7/T6, DCFU290D7/T6 or DCFU290D13/T6, DCFS290D9/T6, DCFUS290D9/T6

(c) Propeller spinner and bulkhead assembly, McCauley D3534/D-4506

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Figure 8-1. Type certificate data sheet.

Airspeed Limits (IAS)	Maneuvering 160 KIAS Maximum structural cruising 212 KIAS Never exceed 241 KIAS Landing gear operating 182 KIAS Landing gear extended 182 KIAS Flaps extended - takeoff 182 KIAS Flaps extended - landing 152 KIAS Minimum control 78 KIAS
C.G. Range (Landing Gear Extended)	(+170.31) to (+179.08) at 8400 lb. (+165.6) at 6100 lb. or less Straight line variation between points given Landing gear retracted moment change: +1113 in./lb.
Empty Wt. C.G. Range	None
Leveling Means	Two screws located on W.L. 93.80 @ sta. 248.25 and sta. 272.65
Maximum Weight	S/N 404-0001 through 404-0200 Landing 8100 lb., takeoff 8400 lb. S/N 404-0201 and up Landing 8100 lb., ramp 8450 lb., takeoff 8400 lb.
No. of Seats	One through eleven (2 at +137.0, 2 at +171.0, 2 at +199.0, 2 at +227.0, 1 at +255.0 and 2 at +296.0) See manufacturer's equipment list for other seating arrangements
Maximum Baggage	250 lb. (+32.0), 350 lb. (+71.0), 400 lb. (+211.0), 400 lb. (+301.0) and 100 lb. (+317.0)
Fuel Capacity	S/N 404-0001 through 404-0200 348.0 gallons (2 wing tanks, 174.0 gallons each, 170.0 gallons usable at +181.2) S/N 404-0201 and up 348.0 gallons (2 wing tanks, 174.0 gallons each, 172.0 gallons usable at +181.2) See NOTE 1 for data on unusable fuel
Oil Capacity	26 quarts (13 quarts in each engine at +129.0; usable 7.0 quarts per engine) See NOTE 1 for data on undrainable oil.
Maximum Operating Altitude	30,000 feet

Control Surface Movements

Wing flaps			Down (Inboard)	35°, ±1°
			Down (Outboard)	23°, +0°, -1°
Main surfaces				
Aileron	Up	25°, +1°, -0°	Down	15°, +1°, -0°
Elevator	Up	24°, +1°, -0°	Down	15°, +1°, -0°
Rudder	Right	32°, +1°, -0°	Left	32°, +1°, -0°
(Read degrees normal to rudder hinge line)				
Tab (main surface in neutral)				
Aileron	Up	15°, +1°, -0°	Down	15°, +1°, -0°
Elevator	Up	4°, +0.5°, -0.0°	Down	14°, +0.0°, -0.5°
Rudder	Right	9°, +0.0°, -0.5°	Left	9°, +1°, -0°
(Read degrees normal to rudder hinge line)				

Serial Nos. Eligible: 404-0001 through 404-0859

Figure 8-1. Type certificate data sheet. (continued)

II - Model 406, Caravan II, (Normal Category), Approved June 27, 1986

Engines: Two Pratt and Whitney Aircraft of Canada, Ltd., PT6A-112 turboprops

Fuel: Aviation turbine fuel ASTM D-1655, Jet A, Jet A-1, or Jet B; MIL-T-5624, JP-4, JP-5; MIL-T-83133, JP-8. Anti-icing additive per MIL-I-27686D, MIL-I-27686E, or Phillips PFA55MB must be blended into the aircraft fuel in concentrations not less than 0.060% or more than 0.15% by volume. For emergency use of aviation gasoline and fueling procedures, refer to approved Airplane Flight Manual.

Engine Limits

Operating Limits	Shaft Horsepower	Ng Gas Generator Speed (% r.p.m.)	Indicated Torque (ft.-lbs.)	Prop Shaft Speed (r.p.m.)	Maximum Permissible Interturbine Temp. (°C)
Takeoff static and max. continous	500	101.6	1382	1900	725
Starting (2 seconds)	-	-	-	-	1090
Maximum reverse	480	101.6	1382	1815	725

Propeller and Propeller Limits:
Two McCauley three-bladed, full-feathering, reversible
Hub: 3GFR34C701
Blade: 93KB-0
Diameter: Not over 93 inches, not under 90-5/8 inches; no further reduction permitted
Pitch at 30-inch station:
Low pitch 18.5°, feathered 85.5°, reverse -13.5°

Airspeed Limits (IAS)

V_{MO} (Maximum operating)	
Sea level to 21,500 ft.	229 knots
M_{MO} Above 21,500 ft.	.52 mach
V_A (Maneuvering)	162 knots
V_{FE} (Flaps extended)	
30° (Landing)	180 knots
20° (Approach)	200 knots
10° (Takeoff)	200 knots
V_{MCA} (Air minimum control speed)	90 knots
V_{LO} (Landing gear operating)	180 knots
V_{LE} (Landing gear extended)	180 knots

C.G. Range (Landing Gear Extended):
(+166.99 in.) to (+180.28 in.) at 6,500 lb. or less (11% to 32% MAC)
(+172.42 in.) to (+180.28 in.) at 9,360 lb. (19.6% to 32% MAC)
Variation is linear between points
Landing gear retracting moment (+1346 in.-lb.)

Empty Wt. C.G. Range: None

Leveling Means: Two screws located on W.L. 93.80 @ sta. 248.25 and sta. 272.65

Maximum Weight

Takeoff	9,360 lb.
Landing	9,360 lb.
Zero fuel (with zero wing locker payload)	8,500 lb.
Ramp	9,435 lb.

Number of Seats: <u>One through fourteen</u>
(2 at +137.0, 2 at +166.0, 2 at +192.0, 2 at +218.0, 2 at +244.0, 2 at +270.0, and 2 at +296.0)
See manufacturer's equipment list for other seating arrangements

Figure 8-1. Type certificate data sheet. (continued)

Maximum Baggage	250 lb. (+32.0), 350 lb. (+71.0), 400 lb (+211.0), 400 lb. (+301.0), and 100 lb. (+317.0)				
Fuel Capacity	3227 lb. (481.5 gal.) total in two wing tanks, 1613.5 lb. (240.75 gal.) each 3183 lb. (475 gal.) usable total, 1591.5 lb. (237.5 gal.) in each tank at sta. +181.9 Fuel weight based on 6.70 lb./gal. See NOTE 1 for data on unusable fuel				
Oil Capacity	5.28 gal. total, 3.00 gal. usable (2.3 gal. in each engine-mounted tank at +142.1) See NOTE 1 for data on undrainable oil				
Maximum Operating Altitude	30,000 ft.				
Control Surface Movements	Elevator (horn faired)	Up	14°, +1°, -0°	Down	17°, +1°, -0°
	Elevator trim tabs	Up	8°, +1°, -0°	Down	10°, +2°, -0°
	Rudder (perpendicular to hinge 0° faired with fin)	Right	32°, +1°, -0°	Left	32°, +1°, -0°
	Rudder trim tab (perpendicular to hinge)	Right	11°, +1°, -0°	Left	16°, +1°, -0°
	Aileron	Up	25°, +1°, -0°	Down	14°, +1°, -0°
	Aileron trim tab	Up	19°, +1°, -0°	Down	19°, +1°, -0°
	Wing flap (inboard)			Down	30°, +1°, -0°
	Wing flap (outboard)			Down	20°, +1°, -0°
Serial Nos. Eligible	406-0001 and on				

Data Pertinent to All Models

Datum: 100.0 inches forward of forward face of fuselage bulkhead forward of rudder pedals.

Certification Basis

Model 404:
Part 23 of the Federal Aviation Regulations effective February 1, 1965, as amended by 23-1 through 23-13 except Subpart B as amended through 23-14; and FAR 23.1385(c) as amended through 23-21; and 23.1327 as amended through 23-23. Findings of equivalent level of safety were made for FAR 23.1189(a), 23.1545, and 23.1583(a). In addition, effective S/N 404-0601, FAR 36 dated December 1, 1969, as amended by 36-1 through 36-4.

In addition to the above certification basis, compliance with ice protection has been demonstrated in accordance with FAR 23.1419 of Amendment 23-14 effective December 20, 1973, when ice protection equipment is installed in accordance with Cessna Drawing 5114400, Factory Kit (FK) No. 194, and Pilot's Operating Handbook and FAA Approved Airplane Flight Manual. Aircraft which have been modified in compliance with Accessory Kit (AK) No. 421-106 are considered to be equivalent to those with Factory Kit (FK) No. 194.

Model 406:
Part 23 of the Federal Aviation Regulations effective February 1, 1965, as amended by 23-1 through 23-13 except Subpart B as amended through 23-14; and 23.427, 23.929, 23.979, 23.1017, 23.1027, 23.1163, 23.1182, 23.1189, 23.1192 as amended through 23-14; 23.951, 23.997, 23.1013, 23.1015, 23.1019(a)(1), 23.1019(a)(2), 23.1019(a)(4), 23.1019(a)(5), 23.1019(b), 23.1183 as amended through 23-15; 23.933, 23.971, 23.977, 23.999, 23.1111, 23.1125, 23.1143, 23.1165, 23.1303 (a through d), 23.1385(c), 23.1549 as amended through 23-17; 23.901, 23.939, 23.943, 23.959, 23.967, 23.973, 23.975, 23.995, 23.1093, 23.1121, 23.1141, 23.1145, 23.1193, 23.1203, 23.1305 (a through u and w), 23.1337 as amended through 23-18; 23.1323, 23.1325, 23.1327, 23.1351, 23.1357, 23.1547 as amended through 23-20; 23.45, 23.49, 23.65, 23.67, 23.77, 23.161, 23.1043, 23.1353, 23.1521 as amended through 23-21; 23.1545 as amended through 23-23; 23.903, 23.1529 as amended through 23-26; SFAR 27 as amended by 27-1 through 27-4; Part 36 as amended by 36-1 through 36-12; SFAR 41C; and Exemption No. 4661 from exact compliance with the requirements of Section 23.207(c). Findings of equivalent level of safety were made for FAR 23.1189(a), and that design of

Figure 8-1. Type certificate data sheet. (continued)

the elevator tab control system provides the level of safety intended by the requirements of FAR 21.21(b)(2) by preventing an unsafe condition. Therefore, FAR 23.629(f), as amended by Amendment 23-23, is applicable to the elevator tab control system, in addition to other requirements in the cited certification basis.

In addition to the above certification basis, compliance with ice protection has been demonstrated in accordance with FAR 23.773 and 23.1419 of Amendment 23-14, FAR 23.1309 as amended through Amendment 23-17, and FAR 23.1416 of Amendment 23-23 when ice protection equipment is installed in accordance with Cessna Drawing 6015006, Factory Kit (FK) No. 194, and Pilot's Operating Handbook and FAA Approved Airplane Flight Manual. Aircraft which have been modified in accordance with Accessory Kit (AK) No. 421-106 are considered to be equivalent to those with Factory Kit (FK) No. 194.
Application for type certificate dated October 9, 1973. Type Certificate No. A25CE issued July 21, 1976, obtained by the manufacturer under delegation option procedures.

Production Basis — Production Certificate No. 312 issued and Delegation Option Manufacturer No. CE-3 authorized to issue airworthiness certificates under delegation option provisions of Part 21 of the Federal Aviation Regulations. Effective February 15, 1985, and on, Production Certificate No. 4 is applicable to all spares production for the Model 404 and to all production on the Model 406.

Equipment — The basic required equipment as prescribed in the applicable airworthiness regulations (see Certification Basis) must be installed in the aircraft for certification. In addition, the following item of equipment is required:

Stall Warning Indicator - Cessna Dwg. 5818008 (404), 5718030 (406) or
Angle-of-Attack Indicator System - Cessna Dwg. 0800302 (404)

NOTE 1. Current weight and balance report together with list of equipment included in certificated empty weight and loading instructions when necessary must be provided for each aircraft at the time of original certification.

The certified empty weight and corresponding center of gravity location must include undrainable oil (not included in Oil Capacity) and unusable fuel as follows:

(a) S/N 404-0001 through 404-0200
Fuel 48 lb. at (+177.6)

S/N 404-0201 and up
Fuel 28 lb. at (+177.6)

S/N 406-0001 and up
Fuel 44 lb. (6.5 gal.) at (+186.7)

(b) Oil 0.0 lb.

NOTE 2. The placards specified in the FAA Approved Airplane Flight Manual must be displayed.

NOTE 3. (404-0001 and up)
1%, by volume, isopropyl alcohol approved for use as fuel anti-icing additive when used as outlined in Cessna Service Letter ME73-25 dated November 2, 1973, or subsequent revisions.

NOTE 4. (S/N 404-0201 and up), (406-0001 and up)
An optional cargo configuration is available which excludes the passenger air distribution and seating. Such airplanes may be operated with passenger seats installed provided the operating rules for supplemental oxygen are complied with.

Figure 8-1. Type certificate data sheet. (continued)

NOTE 5. Aircraft operators must observe limitations and placards shown in the applicable Pilot's Operating Manual and FAA Approved Airplane Flight Manual, or later approved revisions as listed below:

Cessna P/N D1540-3-13:	Model 404 Serial 404-0001 through 404-0136 (1977 Model)
Cessna P/N D1563-1-13:	Model 404 Serial 404-0201 through 404-0246 (1978 Model)
Cessna P/N D1572-2-13PH:	Model 404 Serial 404-0401 through 404-0460 (1979 Model)
Cessna P/N D1583-3-13PH:	Model 404 Serial 404-0601 through 404-0695 (1980 Model)
Cessna P/N D1593-1-13PH:	Model 404 Serial 404-0801 through 404-0859 (1981 Model)
Cessna P/N D1624-13PH:	Model 406 Serial 406-0001 and on

NOTE 6. The Model 406 type design has been duplicated as Model F406 in Type Certificate No. A54EU. The type design file is common between Models 406 and F406 and duplicates of the type design file are maintained by the respective type certificate holders.

.....END.....

Figure 8-1. Type certificate data sheet. (continued)

and not contaminated. Additionally, it is the pilot's responsibility to review the airworthiness certificate, maintenance records, and other required paperwork to verify that the aircraft is indeed airworthy. After each flight, it is recommended that the pilot or mechanic conduct a postflight inspection to detect any problems that might require repair or servicing before the next flight.

Annual/100-Hour Inspections

Title 14 of the Code of Federal Regulations (14 CFR) part 91 discusses the basic requirements for annual and 100-hour inspections. With some exceptions, all aircraft must have a complete inspection annually. Aircraft that are used for commercial purposes and are likely to be used more frequently than noncommercial aircraft must have this complete inspection every 100 hours. The scope and detail of items to be included in annual and 100-hour inspections is included as appendix D of 14 CFR part 43 and shown as Figure 8-2. A properly written checklist, such as the one shown earlier in this chapter, will include all the items of appendix D. Although the scope and detail of annual and 100-hour inspections is identical, there are two significant differences. One difference involves persons authorized to conduct them. A certified airframe and powerplant maintenance technician can conduct a 100-hour inspection, whereas an annual inspection must be conducted by a certified airframe and powerplant maintenance technician with inspection authorization (IA). The other difference involves authorized over-flight of the maximum 100 hours before inspection. An aircraft may be flown up to 10 hours beyond the 100-hour limit if necessary to fly to a destination where the inspection is to be conducted.

Progressive Inspections

Because the scope and detail of an annual inspection is very extensive and could keep an aircraft out of service for a considerable length of time, alternative

Appendix D to Part 43—Scope and Detail of Items (as Applicable to the Particular Aircraft) To Be Included in Annual and 100-Hour Inspections

(a) Each person performing an annual or 100-hour inspection shall, before that inspection, remove or open all necessary inspection plates, access doors, fairing, and cowling. He shall thoroughly clean the aircraft and aircraft engine.

(b) Each person performing an annual or 100-hour inspection shall inspect (where applicable) the following components of the fuselage and hull group:

(1) Fabric and skin—for deterioration, distortion, other evidence of failure, and defective or insecure attachment of fittings.

(2) Systems and components—for improper installation, apparent defects, and unsatisfactory operation.

(3) Envelope, gas bags, ballast tanks, and related parts—for poor condition.

(c) Each person performing an annual or 100-hour inspection shall inspect (where applicable) the following components of the cabin and cockpit group:

(1) Generally—for uncleanliness and loose equipment that might foul the controls.

(2) Seats and safety belts—for poor condition and apparent defects.

(3) Windows and windshields—for deterioration and breakage.

(4) Instruments—for poor condition, mounting, marking, and (where practicable) improper operation.

(5) Flight and engine controls—for improper installation and improper operation.

(6) Batteries—for improper installation and improper charge.

(7) All systems—for improper installation, poor general condition, apparent and obvious defects, and insecurity of attachment.

(d) Each person performing an annual or 100-hour inspection shall inspect (where applicable) components of the engine and nacelle group as follows:

(1) Engine section—for visual evidence of excessive oil, fuel, or hydraulic leaks, and sources of such leaks.

(2) Studs and nuts—for improper torquing and obvious defects.

(3) Internal engine—for cylinder compression and for metal particles or foreign matter on screens and sump drain plugs. If there is

Figure 8-2. Scope and detail of annual and 100-hour inspections.

Appendix D to Part 43—Scope and Detail of Items (as Applicable to the Particular Aircraft) To Be Included in Annual and 100-Hour Inspections (continued)

weak cylinder compression, for improper internal condition and improper internal tolerances.

(4) Engine mount—for cracks, looseness of mounting, and looseness of engine to mount.

(5) Flexible vibration dampeners—for poor condition and deterioration.

(6) Engine controls—for defects, improper travel, and improper safetying.

(7) Lines, hoses, and clamps—for leaks, improper condition, and looseness.

(8) Exhaust stacks—for cracks, defects, and improper attachment.

(9) Accessories—for apparent defects in security of mounting.

(10) All systems—for improper installation, poor general condition, defects, and insecure attachment.

(11) Cowling—for cracks and defects.

(e) Each person performing an annual or 100-hour inspection shall inspect (where applicable) the following components of the landing gear group:

(1) All units—for poor condition and insecurity of attachment.

(2) Shock absorbing devices—for improper oleo fluid level.

(3) Linkages, trusses, and members—for undue or excessive wear fatigue, and distortion.

(4) Retracting and locking mechanism—for improper operation.

(5) Hydraulic lines—for leakage.

(6) Electrical system—for chafing and improper operation of switches.

(7) Wheels—for cracks, defects, and condition of bearings.

(8) Tires—for wear and cuts.

(9) Brakes—for improper adjustment.

(10) Floats and skis—for insecure attachment and obvious or apparent defects.

(f) Each person performing an annual or 100-hour inspection shall inspect (where applicable) all components of the wing and center section assembly for poor general condition, fabric or skin deterioration, distortion, evidence of failure, and insecurity of attachment.

(g) Each person performing an annual or 100-hour inspection shall inspect (where applicable) all components and systems that make up the complete empennage assembly for poor general condition, fabric or skin deterioration, distortion, evidence of failure, insecure attachment, improper component installation, and improper component operation.

(h) Each person performing an annual or 100-hour inspection shall inspect (where applicable) the following components of the propeller group:

(1) Propeller assembly—for cracks, nicks, binds, and oil leakage.

(2) Bolts—for improper torquing and lack of safetying.

(3) Anti-icing devices—for improper operations and obvious defects.

(4) Control mechanisms—for improper operation, insecure mounting, and restricted travel.

(i) Each person performing an annual or 100-hour inspection shall inspect (where applicable) the following components of the radio group:

(1) Radio and electronic equipment—for improper installation and insecure mounting.

(2) Wiring and conduits—for improper routing, insecure mounting, and obvious defects.

(3) Bonding and shielding—for improper installation and poor condition.

(4) Antenna including trailing antenna—for poor condition, insecure mounting, and improper operation.

(j) Each person performing an annual or 100-hour inspection shall inspect (where applicable) each installed miscellaneous item that is not otherwise covered by this listing for improper installation and improper operation.

Figure 8-2. Scope and detail of annual and 100-hour inspections. (continued)

inspection programs designed to minimize down time may be utilized. A progressive inspection program allows an aircraft to be inspected progressively. The scope and detail of an annual inspection is essentially divided into segments or phases (typically four to six). Completion of all the phases completes a cycle that satisfies the requirements of an annual inspection. The advantage of such a program is that any required segment may be completed overnight and thus enable the aircraft to fly daily without missing any revenue earning potential. Progressive inspection programs include routine items such as engine oil changes and detailed items such as flight control cable inspection. Routine items are accomplished each time the aircraft comes in for a phase inspection and detailed items focus on detailed inspection of specific areas. Detailed inspections are typically done once each cycle. A cycle must be completed within 12 months. If all required phases are not completed within 12 months, the remaining phase inspections must be conducted before the end of the 12th month from when the first phase was completed.

Each registered owner or operator of an aircraft desiring to use a progressive inspection program must submit a written request to the FAA Flight Standards District Office (FSDO) having jurisdiction over the area in which the applicant is located. Title 14 of the Code of Federal Regulations (14 CFR) part 91, §91.409(d)

§91.409 Inspections.

(d) **Progressive inspection.** Each registered owner or operator of an aircraft desiring to use a progressive inspection program must submit a written request to the FAA Flight Standards district office having jurisdiction over the area in which the applicant is located, and shall provide—

(1) A certificated mechanic holding an inspection authorization, a certificated airframe repair station, or the manufacturer of the aircraft to supervise or conduct the progressive inspection;

(2) A current inspection procedures manual available and readily understandable to pilot and maintenance personnel containing, in detail—

(i) An explanation of the progressive inspection, including the continuity of inspection responsibility, the making of reports, and the keeping of records and technical reference material;

(ii) An inspection schedule, specifying the intervals in hours or days when routine and detailed inspections will be performed and including instructions for exceeding an inspection interval by not more than 10 hours while en route and for changing an inspection interval because of service experience;

(iii) Sample routine and detailed inspection forms and instructions for their use; and

(iv) Sample reports and records and instructions for their use;

(3) Enough housing and equipment for necessary disassembly and proper inspection of the aircraft; and

(4) Appropriate current technical information for the aircraft.

The frequency and detail of the progressive inspection shall provide for the complete inspection of the aircraft within each 12 calendar months and be consistent with the manufacturer's recommendations, field service experience, and the kind of operation in which the aircraft is engaged. The progressive inspection schedule must ensure that the aircraft, at all times, will be airworthy and will conform to all applicable FAA aircraft specifications, type certificate data sheets, airworthiness directives, and other approved data. If the progressive inspection is discontinued, the owner or operator shall immediately notify the local FAA Flight Standards district office, in writing, of the discontinuance. After the discontinuance, the first annual inspection under §91.409(a)(1) is due within 12 calendar months after the last complete inspection of the aircraft under the progressive inspection. The 100-hour inspection under §91.409(b) is due within 100 hours after that complete inspection. A complete inspection of the aircraft, for the purpose of determining when the annual and 100-hour inspections are due, requires a detailed inspection of the aircraft and all its components in accordance with the progressive inspection. A routine inspection of the aircraft and a detailed inspection of several components is not considered to be a complete inspection.

Figure 8-3. 14 CFR §91.409(d) Progressive inspection.

establishes procedures to be followed for progressive inspections and is shown in Figure 8-3.

Continuous Inspections

Continuous inspection programs are similar to progressive inspection programs, except that they apply to large or turbine-powered aircraft and are therefore more complicated.

Like progressive inspection programs, they require approval by the FAA Administrator. The approval may be sought based upon the type of operation and the CFR parts under which the aircraft will be operated. The maintenance program for commercially operated aircraft must be detailed in the approved operations specifications (OpSpecs) of the commercial certificate holder.

Airlines utilize a continuous maintenance program that includes both routine and detailed inspections. However, the detailed inspections may include different levels of detail. Often referred to as "checks," the A-check, B-check, C-check, and D-checks involve increasing levels of detail. A-checks are the least comprehensive and occur frequently. D-checks, on the other hand, are extremely comprehensive, involving major disassembly, removal, overhaul, and inspection of systems and components. They might occur only three to six times during the service life of an aircraft.

Altimeter and Transponder Inspections

Aircraft that are operated in controlled airspace under instrument flight rules (IFR) must have each altimeter and static system tested in accordance with procedures described in 14 CFR part 43, appendix E, within the preceding 24 calendar months. Aircraft having an air traffic control (ATC) transponder must also have each transponder checked within the preceding 24 months. All these checks must be conducted by appropriately certified individuals.

ATA iSpec 2200

In an effort to standardize the format for the way in which maintenance information is presented in aircraft maintenance manuals, the Air Transport Association of America (ATA) issued specifications for Manufacturers Technical Data. The original specification was called ATA Spec 100. Over the years, Spec 100 has been continuously revised and updated. Eventually, ATA Spec 2100 was developed for electronic documentation. These two specifications evolved into one document called ATA iSpec 2200. As a result of this standardization, maintenance technicians can always find information regarding a particular system in the same section of an aircraft maintenance manual, regardless of manufacturer. For example, if you are seeking information about the electrical system on any aircraft, you will always find that information in section (chapter) 24.

The ATA Specification 100 has the aircraft divided into systems, such as air conditioning, which covers the basic air conditioning system (ATA 21). Numbering in each major system provides an arrangement for breaking the system down into several subsystems. Late model aircraft, both over and under the 12,500 pound designation, have their parts manuals and maintenance manuals arranged according to the ATA coded system.

The following abbreviated table of ATA System, Subsystem, and Titles is included for familiarization purposes.

ATA Specification 100 Systems

Sys.	*Sub.*	*Title*
21		AIR CONDITIONING
21	00	General
21	10	Compression
21	20	Distribution
21	30	Pressurization Control
21	40	Heating
21	50	Cooling
21	60	Temperature Control
21	70	Moisture/Air Contaminate Control

The remainder of this list shows the systems and title with subsystems deleted in the interest of brevity. Consult specific aircraft maintenance manuals for a complete description of the subsystems used in them.

22	AUTO FLIGHT
23	COMMUNICATIONS
24	ELECTRICAL POWER
25	EQUIPMENT/FURNISHINGS
26	FIRE PROTECTION
27	FLIGHT CONTROLS
28	FUEL
29	HYDRAULIC POWER
30	ICE AND RAIN PROTECTION
31	INDICATING/RECORDING SYSTEMS
32	LANDING GEAR
33	LIGHTS
34	NAVIGATION

35 OXYGEN
36 PNEUMATIC
37 VACUUM/PRESSURE
38 WATER/WASTE
39 ELECTRICAL/ELECTRONIC PANELS AND MULTIPURPOSE COMPONENTS
49 AIRBORNE AUXILIARY POWER
51 STRUCTURES
52 DOORS
53 FUSELAGE
54 NACELLES/PYLONS
55 STABILIZERS
56 WINDOWS
57 WINGS
61 PROPELLERS
65 ROTORS
71 POWERPLANT
72 (T) TURBINE/TURBOPROP
72 (R) ENGINE RECIPROCATING
73 ENGINE FUEL AND CONTROL
74 IGNITION
75 BLEED AIR
76 ENGINE CONTROLS
77 ENGINE INDICATING
78 ENGINE EXHAUST
79 ENGINE OIL
80 STARTING
81 TURBINES (RECIPROCATING ENG)
82 WATER INJECTION
83 REMOTE GEAR BOXES (ENG DR)

Keep in mind that not all aircraft will have all these systems installed. Small and simple aircraft have far fewer systems than larger more complex aircraft.

Special Inspections

During the service life of an aircraft, occasions may arise when something out of the ordinary care and use of an aircraft might happen that could possibly affect its airworthiness. When these situations are encountered, special inspection procedures should be followed to determine if damage to the aircraft structure has occurred. The procedures outlined on the following pages are general in nature and are intended to acquaint the aviation mechanic with the areas which should be inspected. As such, they are not all inclusive. When performing any of these special inspections, always follow the detailed procedures in the aircraft maintenance manual. In situations where the manual does not adequately address the situation, seek advice from other maintenance technicians who are highly experienced with them.

Hard or Overweight Landing Inspection

The structural stress induced by a landing depends not only upon the gross weight at the time but also upon the severity of impact. However, because of the difficulty in estimating vertical velocity at the time of contact, it is hard to judge whether or not a landing has been sufficiently severe to cause structural damage. For this reason, a special inspection should be performed after a landing is made at a weight known to exceed the design landing weight or after a rough landing, even though the latter may have occurred when the aircraft did not exceed the design landing weight.

Wrinkled wing skin is the most easily detected sign of an excessive load having been imposed during a landing. Another indication which can be detected easily is fuel leakage along riveted seams. Other possible locations of damage are spar webs, bulkheads, nacelle skin and attachments, firewall skin, and wing and fuselage stringers. If none of these areas show adverse effects, it is reasonable to assume that no serious damage has occurred. If damage is detected, a more extensive inspection and alignment check may be necessary.

Severe Turbulence Inspection/Over "G"

When an aircraft encounters a gust condition, the airload on the wings exceeds the normal wingload supporting the aircraft weight. The gust tends to accelerate the aircraft while its inertia acts to resist this change. If the combination of gust velocity and airspeed is too severe, the induced stress can cause structural damage.

A special inspection should be performed after a flight through severe turbulence. Emphasis should be placed upon inspecting the upper and lower wing surfaces for excessive buckles or wrinkles with permanent set. Where wrinkles have occurred, remove a few rivets and examine the rivet shanks to determine if the rivets have sheared or were highly loaded in shear.

Through the inspection doors and other accessible openings, inspect all spar webs from the fuselage to the tip. Check for buckling, wrinkles, and sheared attachments. Inspect for buckling in the area around the nacelles and in the nacelle skin, particularly at the wing leading edge.

Check for fuel leaks. Any sizeable fuel leak is an indication that an area may have received overloads which have broken the sealant and opened the seams.

If the landing gear was lowered during a period of severe turbulence, inspect the surrounding surfaces carefully for loose rivets, cracks, or buckling. The interior of the wheel well may give further indications of excessive gust conditions. Inspect the top and bottom fuselage skin. An excessive bending moment may have left wrinkles of a diagonal nature in these areas.

Inspect the surface of the empennage for wrinkles, buckling, or sheared attachments. Also, inspect the area of attachment of the empennage to the fuselage. The above inspections cover the critical areas. If excessive damage is noted in any of the areas mentioned, the inspection should be continued until all damage is detected.

Lightning Strike

Although lightning strikes to aircraft are extremely rare, if a strike has occurred, the aircraft must be carefully inspected to determine the extent of any damage that might have occurred. When lightning strikes an aircraft, the electrical current must be conducted through the structure and be allowed to discharge or dissipate at controlled locations. These controlled locations are primarily the aircraft's static discharge wicks, or on more sophisticated aircraft, null field dischargers. When surges of high voltage electricity pass through good electrical conductors, such as aluminum or steel, damage is likely to be minimal or nonexistent. When surges of high voltage electricity pass through non-metallic structures, such as a fiberglass radome, engine cowl or fairing, glass or plastic window, or a composite structure that does not have built-in electrical bonding, burning and more serious damage to the structure could occur. Visual inspection of the structure is required. Look for evidence of degradation, burning or erosion of the composite resin at all affected structures, electrical bonding straps, static discharge wicks and null field dischargers.

Fire Damage

Inspection of aircraft structures that have been subjected to fire or intense heat can be relatively simple if visible damage is present. Visible damage requires repair or replacement. If there is no visible damage, the structural integrity of an aircraft may still have been compromised. Since most structural metallic components of an aircraft have undergone some sort of heat treatment process during manufacture, an exposure to high heat not encountered during normal operations could severely degrade the design strength of the structure. The strength and airworthiness of an aluminum structure that passes a visual inspection but is still suspect can be further determined by use of a conductivity tester. This is a device that uses eddy current and is discussed later in this chapter. Since strength of metals is related to hardness, possible damage to steel structures might be determined by use of a hardness tester such as a Rockwell C hardness tester.

Flood Damage

Like aircraft damaged by fire, aircraft damaged by water can range from minor to severe, depending on the level of the flood water, whether it was fresh or salt water and the elapsed time between the flood occurrence and when repairs were initiated. Any parts that were totally submerged should be completely disassembled, thoroughly cleaned, dried and treated with a corrosion inhibitor. Many parts might have to be replaced, particularly interior carpeting, seats, side panels, and instruments. Since water serves as an electrolyte that promotes corrosion, all traces of water and salt must be removed before the aircraft can again be considered airworthy.

Seaplanes

Because they operate in an environment that accelerates corrosion, seaplanes must be carefully inspected for corrosion and conditions that promote corrosion. Inspect bilge areas for waste hydraulic fluids, water, dirt, drill chips, and other debris. Additionally, since seaplanes often encounter excessive stress from the pounding of rough water at high speeds, inspect for loose rivets and other fasteners; stretched, bent or cracked skins; damage to the float attach fitting; and general wear and tear on the entire structure.

Aerial Application Aircraft

Two primary factors that make inspecting these aircraft different from other aircraft are the corrosive nature of some of the chemicals used and the typical flight profile. Damaging effects of corrosion may be detected in a much shorter period of time than normal use aircraft. Chemicals may soften the fabric or loosen the fabric tapes of fabric covered aircraft. Metal aircraft may need to have the paint stripped, cleaned, and repainted and corrosion treated annually. Leading edges of wings and other areas may require protective coatings or tapes. Hardware may require more frequent replacement.

During peak use, these aircraft may fly up to 50 cycles (takeoffs and landings) or more in a day, most likely from an unimproved or grass runway. This can greatly accelerate the failure of normal fatigue items. Landing gear and related items require frequent inspections. Because these aircraft operate almost continuously at very low altitudes, air filters tend to become obstructed more rapidly.

Special Flight Permits

For an aircraft that does not currently meet airworthiness requirements because of an overdue inspection, damage, expired replacement times for time-limited parts or other reasons, but is capable of safe flight, a special flight permit may be issued. Special flight permits, often referred to as ferry permits, are issued for the following purposes:

- Flying the aircraft to a base where repairs, alterations, or maintenance are to be performed, or to a point of storage.
- Delivering or exporting the aircraft.
- Production flight testing new production aircraft.
- Evacuating aircraft from areas of impending danger.
- Conducting customer demonstration flights in new production aircraft that have satisfactorily completed production flight tests.

Additional information about special flight permits may be found in 14 CFR part 21. Application forms for special flight permits may be requested from the nearest FAA Flight Standards District Office (FSDO).

Nondestructive Inspection/Testing

The preceding information in this chapter provided general information regarding aircraft inspection. The remainder of this chapter deals with several methods often used on specific components or areas on an aircraft when carrying out the more specific inspections. They are referred to as nondestructive inspection (NDI) or nondestructive testing (NDT). The objective of NDI and NDT is to determine the airworthiness of a component without damaging it, which would render it unairworthy. Some of these methods are simple, requiring little additional expertise, while others are highly sophisticated and require that the technician be highly trained and specially certified.

Additional information on NDI may be found by referring to chapter 5 of FAA Advisory Circular (AC) 43.13-1B, Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair. Information regarding training, qualifications, and certification of NDI personnel may be found in FAA Advisory Circular (AC) 65-31A, Training, Qualification and Certification of Non-destructive Inspection (NDI) Personnel.

General Techniques

Before conducting NDI, it is necessary to follow preparatory steps in accordance with procedures specific to that type of inspection. Generally, the parts or areas must be thoroughly cleaned. Some parts must be removed from the aircraft or engine. Others might need to have any paint or protective coating stripped. A complete knowledge of the equipment and procedures is essential and if required, calibration and inspection of the equipment must be current.

Visual Inspection

Visual inspection can be enhanced by looking at the suspect area with a bright light, a magnifying glass, and a mirror (when required). Some defects might be so obvious that further inspection methods are not required. The lack of visible defects does not necessarily mean further inspection is unnecessary. Some defects may lie beneath the surface or may be so small that the human eye, even with the assistance of a magnifying glass, cannot detect them.

Borescope

Inspection by use of a borescope is essentially a visual inspection. A borescope is a device that enables the inspector to see inside areas that could not otherwise be inspected without disassembly. An example of an area that can be inspected with a borescope is the inside of a reciprocating engine cylinder. The borescope can be inserted into an open spark plug hole to detect damaged pistons, cylinder walls, or valves. Another example would be the hot section of a turbine engine to which access could be gained through the hole of a removed igniter or removed access plugs specifically installed for inspection purposes.

Borescopes are available in two basic configurations. The simpler of the two is a rigid type of small diameter telescope with a tiny mirror at the end that enables the user to see around corners. The other type uses fiber optics that enables greater flexibility. Many borescopes provide images that can be displayed on a computer or video monitor for better interpretation of what is being viewed and to record images for future reference. Most borescopes also include a light to illuminate the area being viewed.

Liquid Penetrant Inspection

Penetrant inspection is a nondestructive test for defects open to the surface in parts made of any nonporous material. It is used with equal success on such metals as aluminum, magnesium, brass, copper, cast iron, stainless steel, and titanium. It may also be used on ceramics, plastics, molded rubber, and glass.

Penetrant inspection will detect such defects as surface cracks or porosity. These defects may be caused by fatigue cracks, shrinkage cracks, shrinkage porosity, cold shuts, grinding and heat treat cracks, seams, forging laps, and bursts. Penetrant inspection will also indicate a lack of bond between joined metals.

The main disadvantage of penetrant inspection is that the defect must be open to the surface in order to let the penetrant get into the defect. For this reason, if the part in question is made of material which is magnetic, the use of magnetic particle inspection is generally recommended.

Penetrant inspection uses a penetrating liquid that enters a surface opening and remains there, making it clearly visible to the inspector. It calls for visual examination of the part after it has been processed, increasing the visibility of the defect so that it can be detected. Visibility of the penetrating material is increased by the addition of one of two types of dye, visible or fluorescent.

The visible penetrant kit consists of dye penetrant, dye remover emulsifier, and developer. The fluorescent penetrant inspection kit contains a black light assembly, as well as spray cans of penetrant, cleaner, and developer. The light assembly consists of a power transformer, a flexible power cable, and a hand-held lamp. Due to its size, the lamp may be used in almost any position or location.

Briefly, the steps for performing a penetrant inspection are:

1. Thorough cleaning of the metal surface.
2. Applying penetrant.
3. Removing penetrant with remover emulsifier or cleaner.
4. Drying the part.
5. Applying the developer.
6. Inspecting and interpreting results.

Interpretation of Results

The success and reliability of a penetrant inspection depends upon the thoroughness with which the part was prepared. Several basic principles applying to penetrant inspection are:

1. The penetrant must enter the defect in order to form an indication. It is important to allow sufficient time so the penetrant can fill the defect. The defect must be clean and free of contaminating materials so that the penetrant is free to enter.
2. If all penetrant is washed out of a defect, an indication cannot be formed. During the washing or rinsing operation, prior to development, it is possible that the penetrant will be removed from within the defect, as well as from the surface.
3. Clean cracks are usually easy to detect. Surface openings that are uncontaminated, regardless of how fine, are seldom difficult to detect with the penetrant inspection.
4. The smaller the defect, the longer the penetrating time. Fine crack-like apertures require a longer penetrating time than defects such as pores.
5. When the part to be inspected is made of a material susceptible to magnetism, it should be inspected by a magnetic particle inspection method if the equipment is available.
6. Visible penetrant-type developer, when applied to the surface of a part, will dry to a smooth, even, white coating. As the developer dries, bright red indications will appear where there are surface defects. If no red indications appear, there are no surface defects.
7. When conducting the fluorescent penetrant-type inspection, the defects will show up (under black light) as a brilliant yellow-green color and the sound areas will appear deep blue-violet.
8. It is possible to examine an indication of a defect and to determine its cause as well as its extent. Such an appraisal can be made if something is known about the manufacturing processes to which the part has been subjected.

The size of the indication, or accumulation of penetrant, will show the extent of the defect and the brilliance will be a measure of its depth. Deep cracks will hold more penetrant and will be broader and more brilliant. Very fine openings can hold only small amounts of penetrants and will appear as fine lines. Figure 8-4 shows some of the types of defects that can be located using dry penetrant.

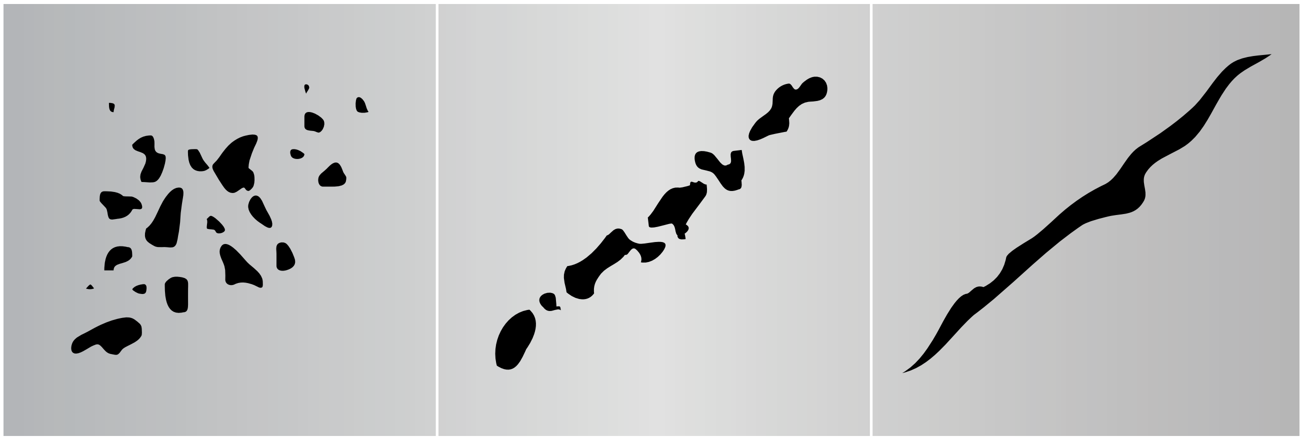

Figure 8-4. Types of defects.

False Indications

With the penetrant inspection, there are no false indications in the sense that they occur in the magnetic particle inspection. There are, however, two conditions which may create accumulations of penetrant that are sometimes confused with true surface cracks and discontinuities.

The first condition involves indications caused by poor washing. If all the surface penetrant is not removed in the washing or rinsing operation following the penetrant dwell time, the unremoved penetrant will be visible. Evidences of incomplete washing are usually easy to identify since the penetrant is in broad areas rather than in the sharp patterns found with true indications. When accumulations of unwashed penetrant are found on a part, the part should be completely reprocessed. Degreasing is recommended for removal of all traces of the penetrant.

False indications may also be created where parts press fit to each other. If a wheel is press fit onto a shaft, penetrant will show an indication at the fit line. This is perfectly normal since the two parts are not meant to be welded together. Indications of this type are easy to identify since they are regular in form and shape.

Eddy Current Inspection

Electromagnetic analysis is a term which describes the broad spectrum of electronic test methods involving the intersection of magnetic fields and circulatory currents. The most widely used technique is the eddy current.

Eddy currents are composed of free electrons under the influence of an induced electromagnetic field which are made to "drift" through metal.

Eddy current is used in aircraft maintenance to inspect jet engine turbine shafts and vanes, wing skins, wheels, bolt holes, and spark plug bores for cracks, heat or frame damage. Eddy current may also be used in repair of aluminum aircraft damaged by fire or excessive heat. Different meter readings will be seen when the same metal is in different hardness states. Readings in the affected area are compared with identical materials in known unaffected areas for comparison. A difference in readings indicates a difference in the hardness state of the affected area. In aircraft manufacturing plants, eddy current is used to inspect castings, stampings, machine parts, forgings, and extrusions. Figure 8-5 shows a technician performing an eddy current inspection on an aluminum wheel half.

Basic Principles

When an alternating current is passed through a coil, it develops a magnetic field around the coil, which in turn induces a voltage of opposite polarity in the coil and opposes the flow of original current. If this coil is placed in such a way that the magnetic field passes

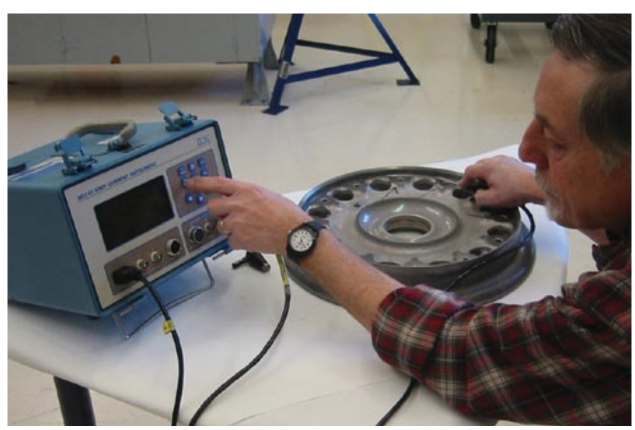

Figure 8-5. Eddy current inspection of wheel half.

through an electrically conducting specimen, eddy currents will be induced into the specimen. The eddy currents create their own field which varies the original field's opposition to the flow of original current. The specimen's susceptibility to eddy currents determines the current flow through the coil. [Figure 8-6]

The magnitude and phase of this counter field is dependent primarily upon the resistance and permeability of the specimen under consideration, and which enables us to make a qualitative determination of various physical properties of the test material. The interaction of the eddy current field with the original field results is a power change that can be measured by utilizing electronic circuitry similar to a Wheatstone bridge.

The specimen is either placed in or passed through the field of an electromagnetic induction coil, and its effect on the impedance of the coil or on the voltage output of one or more test coils is observed. The process, which involves electric fields made to explore a test piece for various conditions, involves the transmission of energy through the specimen much like the transmission of x-rays, heat, or ultrasound.

Eddy current inspection can frequently be performed without removing the surface coatings such as primer, paint, and anodized films. It can be effective in detecting surface and subsurface corrosion, pots and heat treat condition.

Ultrasonic Inspection

Ultrasonic detection equipment makes it possible to locate defects in all types of materials. Minute cracks, checks, and voids too small to be seen by x-ray can be located by ultrasonic inspection. An ultrasonic test instrument requires access to only one surface of the material to be inspected and can be used with either straight line or angle beam testing techniques.

Two basic methods are used for ultrasonic inspection. The first of these methods is immersion testing. In this method of inspection, the part under examination and the search unit are totally immersed in a liquid couplant, which may be water or any other suitable fluid.

The second method is called contact testing, which is readily adapted to field use and is the method discussed in this chapter. In this method, the part under examination and the search unit are coupled with a viscous material, liquid or a paste, which wets both the face of the search unit and the material under examination.

There are three basic ultrasonic inspection methods: (1) pulse echo; (2) through transmission; and (3) resonance.

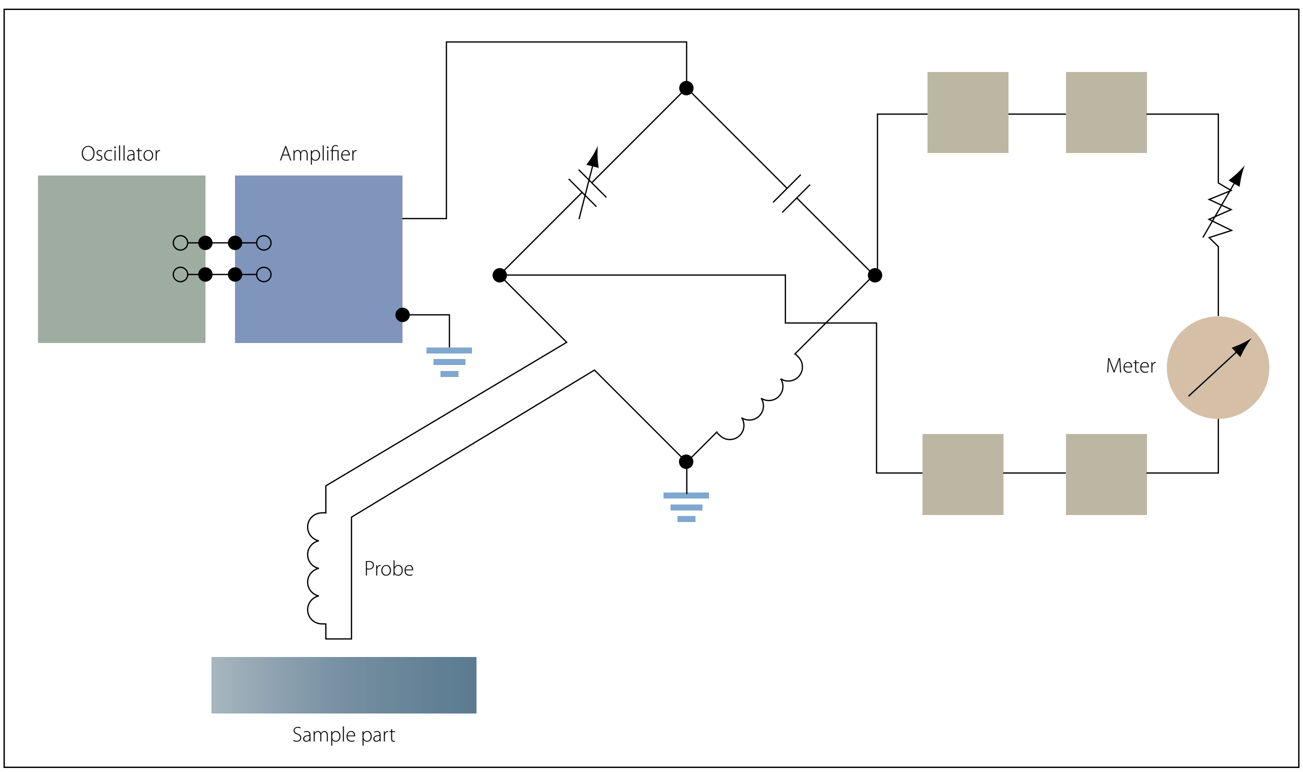

Figure 8-6. Eddy current inspection circuit.

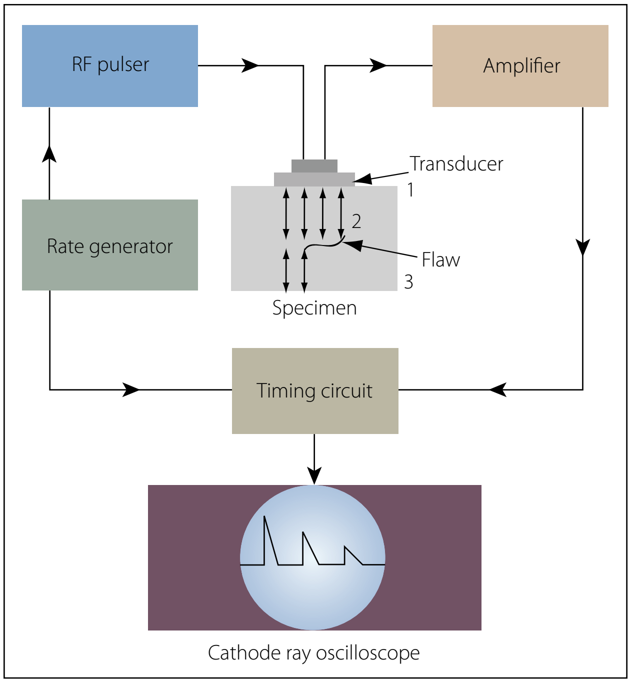

Figure 8-7. Block diagram of basic pulse-echo system.

Pulse Echo

Flaws are detected by measuring the amplitude of signals reflected and the time required for these signals to travel between specific surfaces and the discontinuity. [Figure 8-7]

The time base, which is triggered simultaneously with each transmission pulse, causes a spot to sweep across the screen of the cathode ray tube (CRT). The spot sweeps from left to right across the face of the scope 50 to 5,000 times per second, or higher if required for high speed automated scanning. Due to the speed of the cycle of transmitting and receiving, the picture on the oscilloscope appears to be stationary.

A few microseconds after the sweep is initiated, the rate generator electrically excites the pulser, and the pulser in turn emits an electrical pulse. The transducer converts this pulse into a short train of ultrasonic sound waves. If the interfaces of the transducer and the specimen are properly oriented, the ultrasound will be reflected back to the transducer when it reaches the internal flaw and the opposite surface of the specimen. The time interval between the transmission of the initial impulse and the reception of the signals from within the specimen are measured by the timing circuits. The reflected pulse received by the transducer is amplified, then transmitted to and displayed on the instrument screen. The pulse is displayed in the same relationship to the front and back pulses as the flaw is in relation to the front and back surfaces of the specimen. [Figure 8-8]

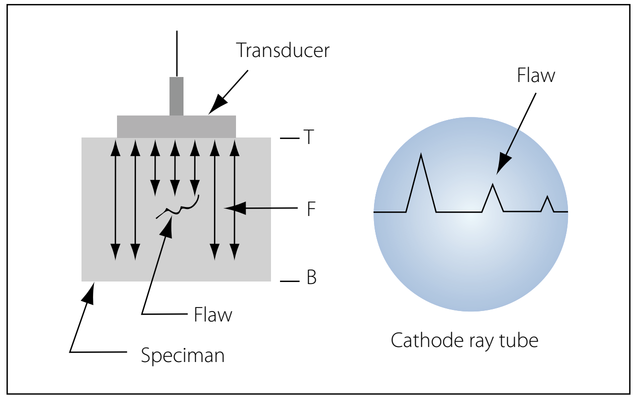

Figure 8-8. Pulse-echo display in relationship to flaw detection.

Pulse-echo instruments may also be used to detect flaws not directly underneath the probe by use of the angle-beam testing method. Angle beam testing differs from straight beam testing only in the manner in which the ultrasonic waves pass through the material being tested. As shown in Figure 8-9, the beam is projected into the material at an acute angle to the surface by means of a crystal cut at an angle and mounted in plastic. The beam or a portion thereof reflects successively from the surfaces of the material or any other discontinuity, including the edge of the piece. In straight beam testing, the horizontal distance on the screen between the initial pulse and the first back reflection represents the thickness of the piece; while in angle beam testing, this distance represents the width of the material between the searching unit and the opposite edge of the piece.

Through Transmission

Through transmission inspection uses two transducers, one to generate the pulse and another placed on the opposite surface to receive it. A disruption in the sound path will indicate a flaw and be displayed on the instrument screen. Through transmission is less sensitive to small defects than the pulse-echo method.

Resonance

This system differs from the pulse method in that the frequency of transmission may be continuously varied. The resonance method is used principally for thickness measurements when the two sides of the material being tested are smooth and parallel and the backside is inaccessible. The point at which the frequency matches the resonance point of the material being tested is the thickness determining factor.

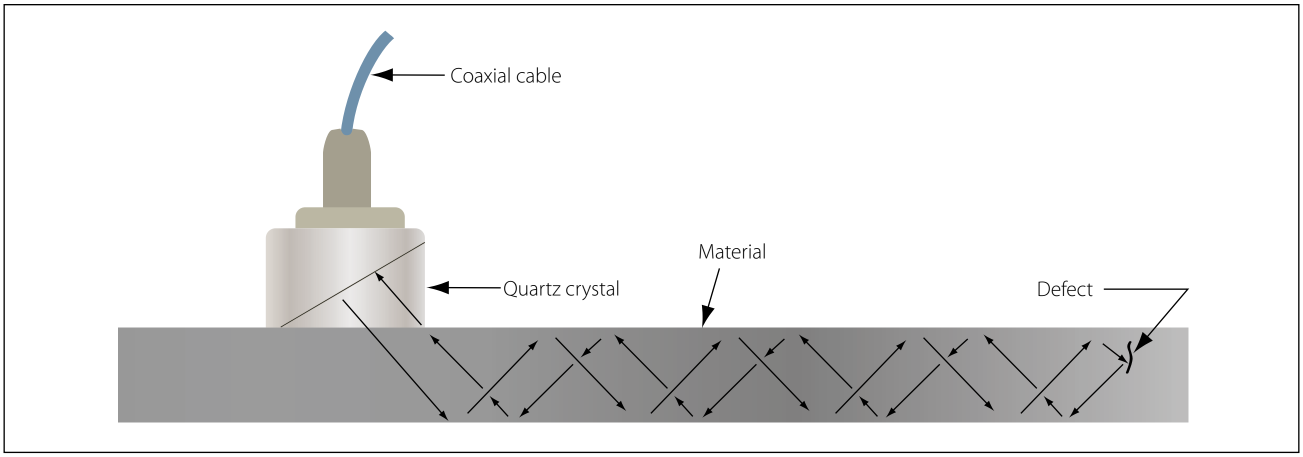

Figure 8-9. Pulse-echo angle beam testing.

It is necessary that the frequency of the ultrasonic waves corresponding to a particular dial setting be accurately known. Checks should be made with standard test blocks to guard against possible drift of frequency.

If the frequency of an ultrasonic wave is such that its wavelength is twice the thickness of a specimen (fundamental frequency), then the reflected wave will arrive back at the transducer in the same phase as the original transmission so that strengthening of the signal will occur. This results from constructive interference or a resonance and is shown as a high amplitude value on the indicating screen. If the frequency is increased such that three times the wavelength equals four times the thickness, the reflected signal will return completely out of phase with the transmitted signal and cancellation will occur. Further increase of the frequency causes the wavelength to be equal to the thickness again and gives a reflected signal in phase with the transmitted signal and a resonance once more.

By starting at the fundamental frequency and gradually increasing the frequency, the successive cancellations and resonances can be noted and the readings used to check the fundamental frequency reading. [Figure 8-10]

In some instruments, the oscillator circuit contains a motor driven capacitor which changes the frequency of the oscillator. [Figure 8-11] In other instruments, the frequency is changed by electronic means.

The change in frequency is synchronized with the horizontal sweep of a CRT. The horizontal axis thus represents a frequency range. If the frequency range contains resonances, the circuitry is arranged to present these vertically. Calibrated transparent scales are then placed in front of the tube, and the thickness can be read directly. The instruments normally operate

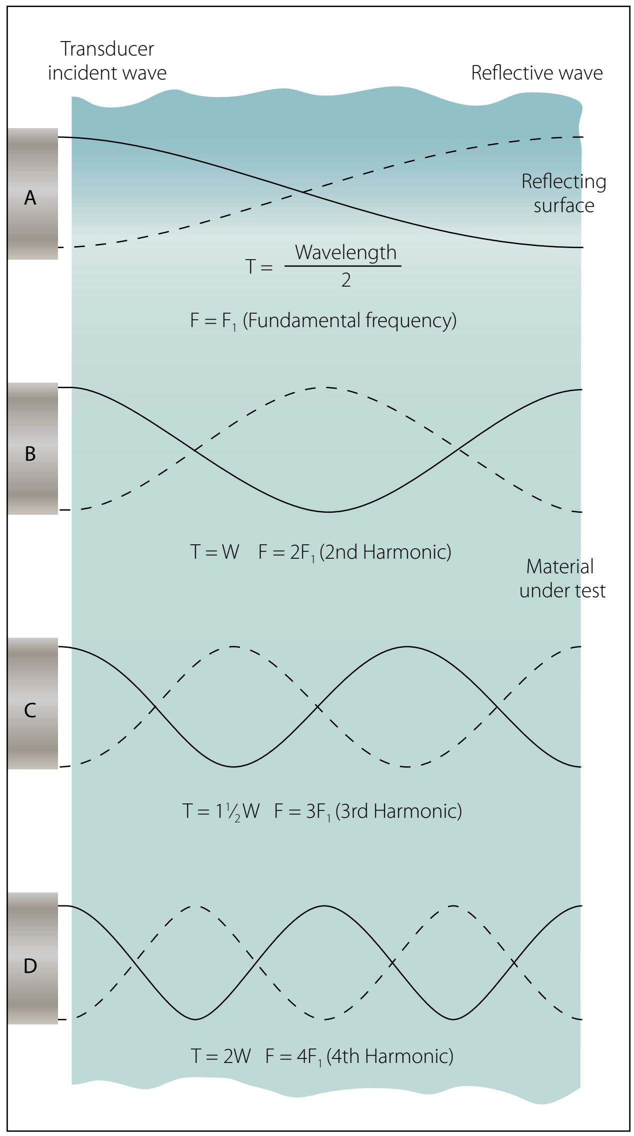

Figure 8-10. Conditions of ultrasonic resonance in a metal plate.

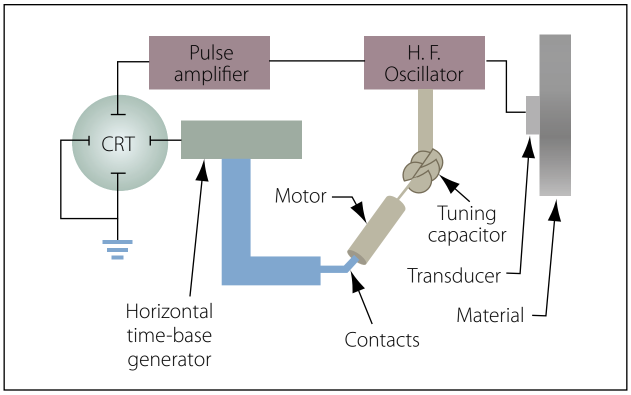

Figure 8-11. Block diagram of resonance thickness measuring system.

between 0.25 millicycle (mc) and 10 mc in four or five bands.

The resonance thickness instrument can be used to test the thickness of such metals as steel, cast iron, brass, nickel, copper, silver, lead, aluminum, and magnesium. In addition, areas of corrosion or wear on tanks, tubing, airplane wing skins, and other structures or products can be located and evaluated.

Direct reading dial-operated units are available that measure thickness between 0.025 inch and 3 inches with an accuracy of better than ±1 percent.

Ultrasonic inspection requires a skilled operator who is familiar with the equipment being used as well as the inspection method to be used for the many different parts being tested. [Figure 8-12]

Figure 8-12. Ultrasonic inspection of a composite structure.

Acoustic Emission Inspection

Acoustic emission is an NDI technique that involves the placing of acoustic emission sensors at various locations on an aircraft structure and then applying a load or stress. The materials emit sound and stress waves that take the form of ultrasonic pulses. Cracks and areas of corrosion in the stressed airframe structure emit sound waves which are registered by the sensors. These acoustic emission bursts can be used to locate flaws and to evaluate their rate of growth as a function of applied stress. Acoustic emission testing has an advantage over other NDI methods in that it can detect and locate all of the activated flaws in a structure in one test. Because of the complexity of aircraft structures, application of acoustic emission testing to aircraft has required a new level of sophistication in testing technique and data interpretation.

Magnetic Particle Inspection

Magnetic particle inspection is a method of detecting invisible cracks and other defects in ferromagnetic materials such as iron and steel. It is not applicable to nonmagnetic materials.

In rapidly rotating, reciprocating, vibrating, and other highly stressed aircraft parts, small defects often develop to the point that they cause complete failure of the part. Magnetic particle inspection has proven extremely reliable for the rapid detection of such defects located on or near the surface. With this method of inspection, the location of the defect is indicated and the approximate size and shape are outlined.

The inspection process consists of magnetizing the part and then applying ferromagnetic particles to the surface area to be inspected. The ferromagnetic particles (indicating medium) may be held in suspension in a liquid that is flushed over the part; the part may be immersed in the suspension liquid; or the particles, in dry powder form, may be dusted over the surface of the part. The wet process is more commonly used in the inspection of aircraft parts.

If a discontinuity is present, the magnetic lines of force will be disturbed and opposite poles will exist on either side of the discontinuity. The magnetized particles thus form a pattern in the magnetic field between the opposite poles. This pattern, known as an "indication," assumes the approximate shape of the surface projection of the discontinuity. A discontinuity may be defined as an interruption in the normal physical structure or configuration of a part, such as a crack, forging lap, seam, inclusion, porosity, and the like.

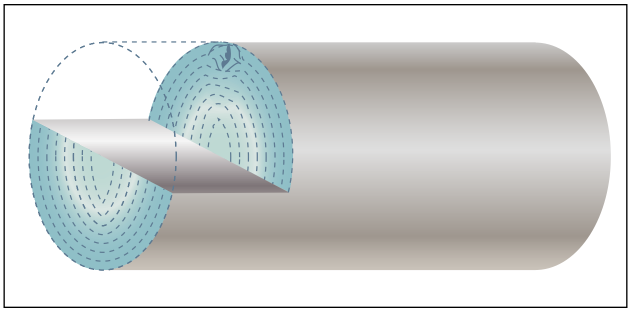

Figure 8-13. Flux leakage at transverse discontinuity.

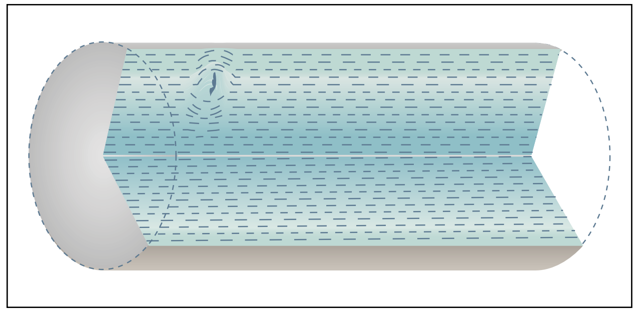

Figure 8-14. Flux leakage at longitudinal discontinuity.

A discontinuity may or may not affect the usefulness of a part.

Development of Indications

When a discontinuity in a magnetized material is open to the surface, and a magnetic substance (indicating medium) is available on the surface, the flux leakage at the discontinuity tends to form the indicating medium into a path of higher permeability. (Permeability is a term used to refer to the ease with which a magnetic flux can be established in a given magnetic circuit.) Because of the magnetism in the part and the adherence of the magnetic particles to each other, the indication remains on the surface of the part in the form of an approximate outline of the discontinuity that is immediately below it.

The same action takes place when the discontinuity is not open to the surface, but since the amount of flux leakage is less, fewer particles are held in place and a fainter and less sharply defined indication is obtained.

If the discontinuity is very far below the surface, there may be no flux leakage and no indication on the surface. The flux leakage at a transverse discontinuity is shown in Figure 8-13. The flux leakage at a longitudinal discontinuity is shown in Figure 8-14.

Types of Discontinuities Disclosed

The following types of discontinuities are normally detected by the magnetic particle test: cracks, laps, seams, cold shuts, inclusions, splits, tears, pipes, and voids. All of these may affect the reliability of parts in service.

Cracks, splits, bursts, tears, seams, voids, and pipes are formed by an actual parting or rupture of the solid metal. Cold shuts and laps are folds that have been formed in the metal, interrupting its continuity.

Inclusions are foreign material formed by impurities in the metal during the metal processing stages. They may consist, for example, of bits of furnace lining picked up during the melting of the basic metal or of other foreign constituents. Inclusions interrupt the continuity of the metal because they prevent the joining or welding of adjacent faces of the metal.

Preparation of Parts for Testing

Grease, oil, and dirt must be cleaned from all parts before they are tested. Cleaning is very important since any grease or other foreign material present can produce nonrelevant indications due to magnetic particles adhering to the foreign material as the suspension drains from the part.

Grease or foreign material in sufficient amount over a discontinuity may also prevent the formation of a pattern at the discontinuity. It is not advisable to depend upon the magnetic particle suspension to clean the part. Cleaning by suspension is not thorough and any foreign materials so removed from the part will contaminate the suspension, thereby reducing its effectiveness.

In the dry procedure, thorough cleaning is absolutely necessary. Grease or other foreign material will hold the magnetic powder, resulting in nonrelevant indications and making it impossible to distribute the indicating medium evenly over the part's surface.

All small openings and oil holes leading to internal passages or cavities should be plugged with paraffin or other suitable nonabrasive material.

Coatings of cadmium, copper, tin, and zinc do not interfere with the satisfactory performance of magnetic particle inspection, unless the coatings are unusually heavy or the discontinuities to be detected are unusually small.

Chromium and nickel plating generally will not interfere with indications of cracks open to the surface of the base metal but will prevent indications of fine discontinuities, such as inclusions.

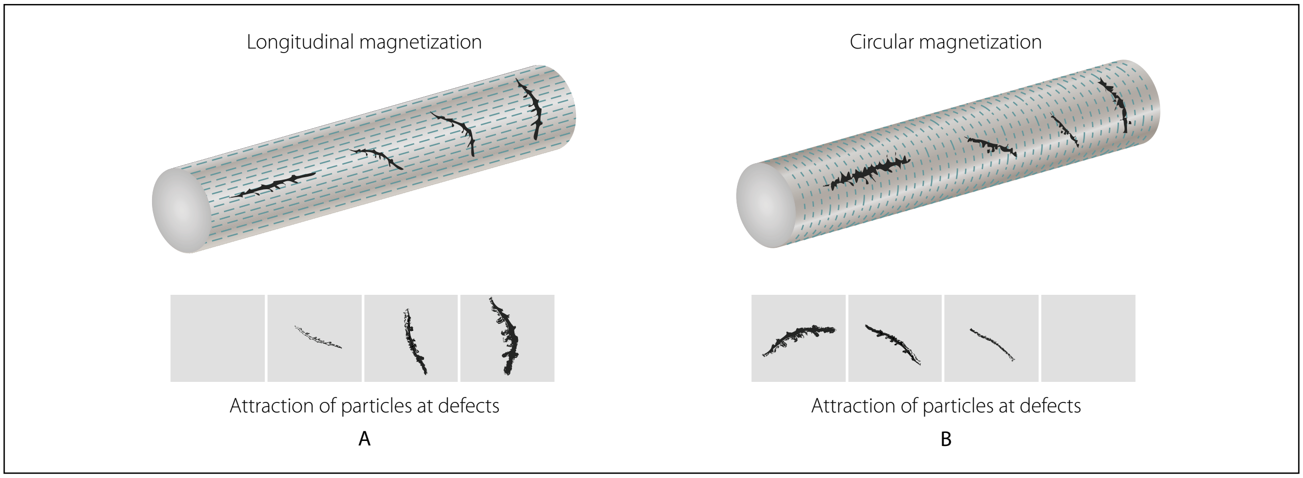

Figure 8-15. Effect of flux direction on strength of indication.

Because it is more strongly magnetic, nickel plating is more effective than chromium plating in preventing the formation of indications.

Effect of Flux Direction

To locate a defect in a part, it is essential that the magnetic lines of force pass approximately perpendicular to the defect. It is therefore necessary to induce magnetic flux in more than one direction since defects are likely to exist at any angle to the major axis of the part. This requires two separate magnetizing operations, referred to as circular magnetization and longitudinal magnetization. The effect of flux direction is illustrated in Figure 8-15.

Circular magnetization is the induction of a magnetic field consisting of concentric circles of force about and within the part which is achieved by passing electric current through the part. This type of magnetization will locate defects running approximately parallel to the axis of the part. Figure 8-16 illustrates circular magnetization of a camshaft.

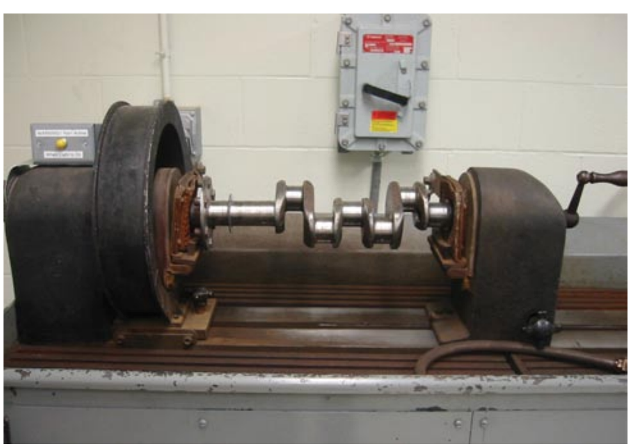

Figure 8-16. Circular magnetization of a camshaft.

In longitudinal magnetization, the magnetic field is produced in a direction parallel to the long axis of the part. This is accomplished by placing the part in a solenoid excited by electric current. The metal part then becomes the core of an electromagnet and is magnetized by induction from the magnetic field created in the solenoid.

In longitudinal magnetization of long parts, the solenoid must be moved along the part in order to magnetize it. [Figure 8-17] This is necessary to ensure adequate field strength throughout the entire length of the part.

Solenoids produce effective magnetization for approximately 12 inches from each end of the coil, thus accommodating parts or sections approximately 30 inches in length. Longitudinal magnetization equivalent to that obtained by a solenoid may be accomplished by wrapping a flexible electrical conductor around the part. Although this method is not as convenient, it has

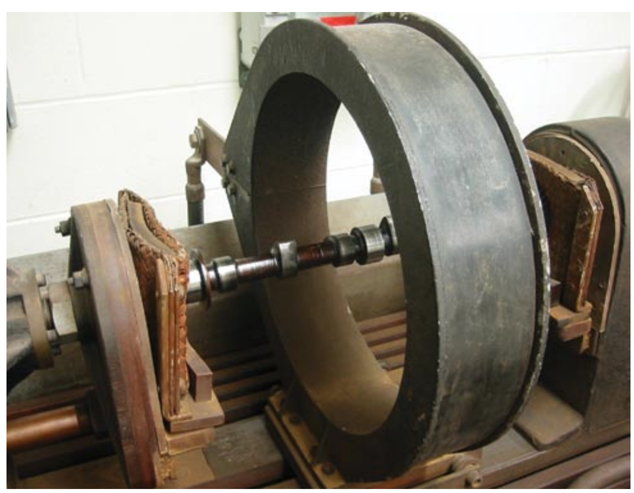

Figure 8-17. Longitudinal magnetization of crankshaft (solenoid method).

an advantage in that the coils conform more closely to the shape of the part, producing a somewhat more uniform magnetization.

The flexible coil method is also useful for large or irregularly shaped parts for which standard solenoids are not available.

Effect of Flux Density

The effectiveness of the magnetic particle inspection also depends on the flux density or field strength at the surface of the part when the indicating medium is applied. As the flux density in the part is increased, the sensitivity of the test increases because of the greater flux leakages at discontinuities and the resulting improved formation of magnetic particle patterns.

Excessively high flux densities may form nonrelevant indications; for example, patterns of the grain flow in the material. These indications will interfere with the detection of patterns resulting from significant discontinuities. It is therefore necessary to use a field strength high enough to reveal all possible harmful discontinuities but not strong enough to produce confusing nonrelevant indications.

Magnetizing Methods

When a part is magnetized, the field strength in the part increases to a maximum for the particular magnetizing force and remains at this maximum as long as the magnetizing force is maintained.

When the magnetizing force is removed, the field strength decreases to a lower residual value depending on the magnetic properties of the material and the shape of the part. These magnetic characteristics determine whether the continuous or residual method is used in magnetizing the part.

In the continuous inspection method, the part is magnetized and the indicating medium applied while the magnetizing force is maintained. The available flux density in the part is thus at a maximum. The maximum value of flux depends directly upon the magnetizing force and the permeability of the material of which the part is made.

The continuous method may be used in practically all circular and longitudinal magnetization procedures. The continuous procedure provides greater sensitivity than the residual procedure, particularly in locating subsurface discontinuities. The highly critical nature of aircraft parts and assemblies and the necessity for subsurface inspection in many applications have resulted in the continuous method being more widely used.

Inasmuch as the continuous procedure will reveal more nonsignificant discontinuities than the residual procedure, careful and intelligent interpretation and evaluation of discontinuities revealed by this procedure are necessary.

The residual inspection procedure involves magnetization of the part and application of the indicating medium after the magnetizing force has been removed. This procedure relies on the residual or permanent magnetism in the part and is more practical than the continuous procedure when magnetization is accomplished by flexible coils wrapped around the part.

In general, the residual procedure is used only with steels which have been heat treated for stressed applications.

Identification of Indications

The correct evaluation of the character of indications is extremely important but is sometimes difficult to make from observation of the indications alone. The principal distinguishing features of indications are shape, buildup, width, and sharpness of outline. These characteristics are more valuable in distinguishing between types of discontinuities than in determining their severity. Careful observation of the character of the magnetic particle pattern should always be included in the complete evaluation of the significance of an indicated discontinuity.

The most readily distinguished indications are those produced by cracks open to the surface. These discontinuities include fatigue cracks, heat treat cracks, shrink cracks in welds and castings, and grinding cracks. An example of a fatigue crack is shown in Figure 8-18.

Magnaglo Inspection

Magnaglo inspection is similar to the preceding method but differs in that a fluorescent particle solution is used and the inspection is made under black light. Efficiency of inspection is increased by the neon-like glow of defects allowing smaller flaw indications to be seen. This is an excellent method for use on gears, threaded parts, and aircraft engine components. The reddish brown liquid spray or bath that is used consists of Magnaglo paste mixed with a light oil at the ratio of 0.10 to 0.25 ounce of paste per gallon of oil.

After inspection, the part must be demagnetized and rinsed with a cleaning solvent.

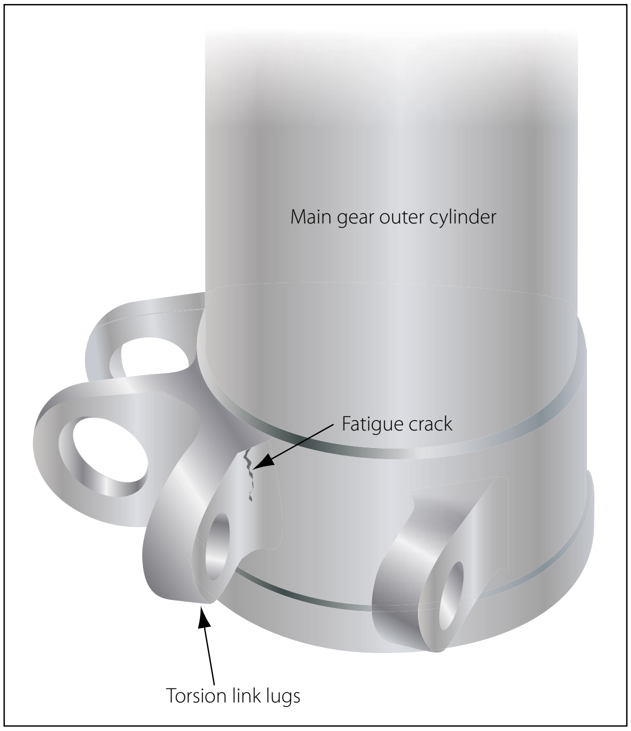

Figure 8-18. Fatigue crack in a landing gear.

Magnetizing Equipment

Fixed (Nonportable) General Purpose Unit

A fixed general purpose unit is shown in Figure 8-19. This unit provides direct current for wet continuous or residual magnetization procedures. Circular or longitudinal magnetization may be used and it may be powered with rectified alternating current (ac), as well as direct current (dc). The contact heads provide the electrical terminals for circular magnetization. One head is fixed in position with its contact plate mounted on a shaft surrounded by a pressure spring, so that the plate may be moved longitudinally. The plate is maintained in the extended position by the spring until pressure transmitted through the work from the movable head forces it back.

The motor driven movable head slides horizontally in longitudinal guides and is controlled by a switch. The spring allows sufficient overrun of the motor driven head to avoid jamming it and also provides pressure on the ends of the work to ensure good electrical contact.

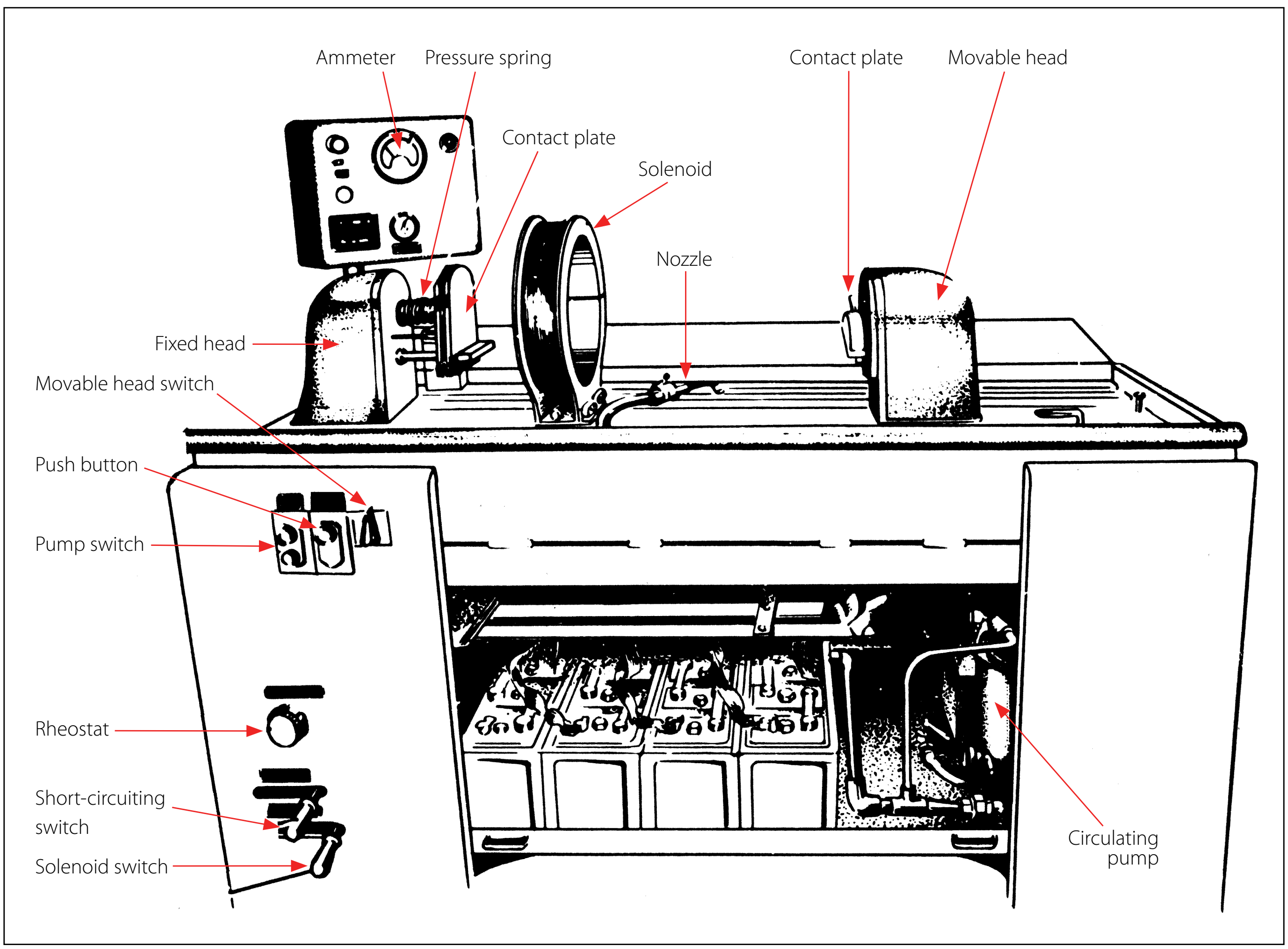

Figure 8-19. Fixed general-purpose magnetizing unit.

A plunger operated switch in the fixed head cuts out the forward motion circuit of the movable head motor when the spring has been properly compressed.

In some units the movable head is hand operated, and the contact plate is sometimes arranged for operation by an air ram. Both contact plates are fitted with various fixtures for supporting the work.

The magnetizing circuit is closed by depressing a pushbutton on the front of the unit. It is set to open automatically, usually after about one-half second.

The strength of the magnetizing current may be set manually to the desired value by means of the rheostat or increased to the capacity of the unit by the rheostat short circuiting switch. The current utilized is indicated on the ammeter.

Longitudinal magnetization is produced by the solenoid, which moves in the same guide rail as the movable head and is connected in the electrical circuit by means of a switch.

The suspension liquid is contained in a sump tank and is agitated and circulated by a pump. The suspension is applied to the work through a nozzle. The suspension drains from the work through a nonmetallic grill into a collecting pan that leads back to the sump. The circulating pump is operated by a pushbutton switch.

Portable General Purpose Unit

It is often necessary to perform the magnetic particle inspection at locations where fixed general purpose equipment is not available or to perform an inspection on members of aircraft structures without removing them from the aircraft. It is particularly useful for inspecting landing gear and engine mounts suspected of having developed cracks in service. Portable units supply both alternating current and direct current magnetization.

This unit is only a source of magnetizing and demagnetizing current and does not provide a means for supporting the work or applying the suspension. It operates on 200 volt, 60 cycle, alternating current and contains a rectifier for producing direct current when required. [Figure 8-20]

The magnetizing current is supplied through the flexible cables. The cable terminals may be fitted with prods, as shown in the illustration, or with contact clamps. Circular magnetization may be developed by using either the prods or clamps.

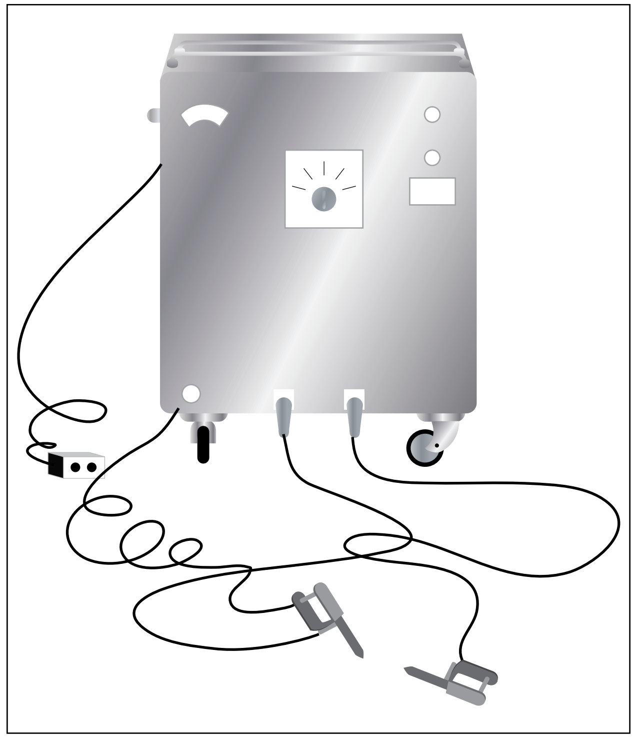

Figure 8-20. Portable general purpose unit.

Longitudinal magnetization is developed by wrapping the cable around the part.

The strength of the magnetizing current is controlled by an eight point tap switch, and the time duration for which it is applied is regulated by an automatic cutoff similar to that used in the fixed general purpose unit.

This portable unit also serves as a demagnetizer and supplies high amperage low voltage alternating current for this purpose. For demagnetization, the alternating current is passed through the part and gradually reduced by means of a current reducer.

In testing large structures with flat surfaces where current must be passed through the part, it is sometimes impossible to use contact clamps. In such cases, contact prods are used.

Prods can be used with the fixed general purpose unit as well as the portable unit. The part or assembly being tested may be held or secured above the standard unit and the suspension hosed onto the area; excess suspension drains into the tank. The dry procedure may also be used.

Prods should be held firmly against the surface being tested. There is a tendency for a high amperage current to cause burning at contact areas, but with proper care, such burning is usually slight. For applications where prod magnetization is acceptable, slight burning is normally acceptable.

Indicating Mediums

The various types of indicating mediums available for magnetic particle inspection may be divided into two general material types: wet and dry. The basic requirement for any indicating medium is that it produce acceptable indications of discontinuities in parts.

The contrast provided by a particular indicating medium on the background or part surface is particularly important. The colors most extensively used are black and red for the wet procedure and black, red, and gray for the dry procedure.

For acceptable operation, the indicating medium must be of high permeability and low retentivity. High permeability ensures that a minimum of magnetic energy will be required to attract the material to flux leakage caused by discontinuities. Low retentivity ensures that the mobility of the magnetic particles will not be hindered by the particles themselves becoming magnetized and attracting one another.

Demagnetizing

The permanent magnetism remaining after inspection must be removed by a demagnetization operation if the part is to be returned to service. Parts of operating mechanisms must be demagnetized to prevent magnetized parts from attracting filings, grindings, or chips inadvertently left in the system, or steel particles resulting from operational wear.

An accumulation of such particles on a magnetized part may cause scoring of bearings or other working parts. Parts of the airframe must be demagnetized so they will not affect instruments.

Demagnetization between successive magnetizing operations is not normally required unless experience indicates that omission of this operation results in decreased effectiveness for a particular application. Demagnetization may be accomplished in a number of different ways. A convenient procedure for aircraft parts involves subjecting the part to a magnetizing force that is continually reversing in direction and, at the same time, gradually decreasing in strength. As the decreasing magnetizing force is applied first in one direction and then the other, the magnetization of the part also decreases.

Standard Demagnetizing Practice

The simplest procedure for developing a reversing and gradually decreasing magnetizing force in a part involves the use of a solenoid coil energized by alternating current. As the part is moved away from the alternating field of the solenoid, the magnetism in the part gradually decreases.

A demagnetizer whose size approximates that of the work should be used. For maximum effectiveness, small parts should be held as close to the inner wall of the coil as possible.

Parts that do not readily lose their magnetism should be passed slowly in and out of the demagnetizer several times and, at the same time, tumbled or rotated in various directions. Allowing a part to remain in the demagnetizer with the current on accomplishes very little practical demagnetization.

The effective operation in the demagnetizing procedure is that of slowly moving the part out of the coil and away from the magnetizing field strength. As the part is withdrawn, it should be kept directly opposite the opening until it is 1 or 2 feet from the demagnetizer.

The demagnetizing current should not be cut off until the part is 1 or 2 feet from the opening as the part may be remagnetized if current is removed too soon.

Another procedure used with portable units is to pass alternating current through the part being demagnetized, while gradually reducing the current to zero.

Radiographic

X and gamma radiations, because of their unique ability to penetrate material and disclose discontinuities, have been applied to the radiographic (x-ray) inspection of metal fabrications and nonmetallic products.

The penetrating radiation is projected through the part to be inspected and produces an invisible or latent image in the film. When processed, the film becomes a radiograph or shadow picture of the object. This inspection medium and portable unit provides a fast and reliable means for checking the integrity of airframe structures and engines. [Figure 8-21]

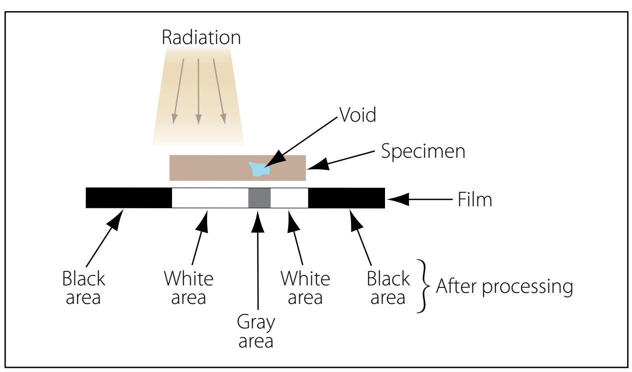

Figure 8-21. Radiograph.

Radiographic Inspection

Radiographic inspection techniques are used to locate defects or flaws in airframe structures or engines with little or no disassembly. This is in marked contrast to other types of nondestructive testing which usually require removal, disassembly, and stripping of paint from the suspected part before it can be inspected. Due to the radiation risks associated with x-ray, extensive training is required to become a qualified radiographer. Only qualified radiographers are allowed to operate the x-ray units.

Three major steps in the x-ray process discussed in subsequent paragraphs are: (1) exposure to radiation, including preparation, (2) processing of film, and (3) interpretation of the radiograph.

Preparation and Exposure

The factors of radiographic exposure are so interdependent that it is necessary to consider all factors for any particular radiographic exposure. These factors include but are not limited to the following:

- Material thickness and density
- Shape and size of the object
- Type of defect to be detected
- Characteristics of x-ray machine used
- The exposure distance
- The exposure angle
- Film characteristics
- Types of intensifying screen, if used

Knowledge of the x-ray unit's capabilities should form a background for the other exposure factors. In addition to the unit rating in kilovoltage, the size, portability, ease of manipulation, and exposure particulars of the available equipment should be thoroughly understood.

Previous experience on similar objects is also very helpful in the determination of the overall exposure techniques. A log or record of previous exposures will provide specific data as a guide for future radiographs.

Film Processing

After exposure to x-rays, the latent image on the film is made permanently visible by processing it successively through a developer chemical solution, an acid bath, and a fixing bath, followed by a clear water wash.

Radiographic Interpretation

From the standpoint of quality assurance, radiographic interpretation is the most important phase of radiography. It is during this phase that an error in judgment can produce disastrous consequences. The efforts of the whole radiographic process are centered in this phase; the part or structure is either accepted or rejected. Conditions of unsoundness or other defects which are overlooked, not understood, or improperly interpreted can destroy the purpose and efforts of radiography and can jeopardize the structural integrity of an entire aircraft. A particular danger is the false sense of security imparted by the acceptance of a part or structure based on improper interpretation.

As a first impression, radiographic interpretation may seem simple, but a closer analysis of the problem soon dispels this impression. The subject of interpretation is so varied and complex that it cannot be covered adequately in this type of document. Instead, this chapter gives only a brief review of basic requirements for radiographic interpretation, including some descriptions of common defects.

Experience has shown that, whenever possible, radiographic interpretation should be conducted close to the radiographic operation. When viewing radiographs, it is helpful to have access to the material being tested. The radiograph can thus be compared directly with the material being tested, and indications due to such things as surface condition or thickness variations can be immediately determined.

The following paragraphs present several factors which must be considered when analyzing a radiograph.

There are three basic categories of flaws: voids, inclusions, and dimensional irregularities. The last category, dimensional irregularities, is not pertinent to these discussions because its prime factor is one of degree, and radiography is not exact. Voids and inclusions may appear on the radiograph in a variety of forms ranging from a two-dimensional plane to a three-dimensional sphere. A crack, tear, or cold shut will most nearly resemble a two-dimensional plane, whereas a cavity will look like a three-dimensional sphere. Other types of flaws, such as shrink, oxide inclusions, porosity, and so forth, will fall somewhere between these two extremes of form.

It is important to analyze the geometry of a flaw, especially for items such as the sharpness of terminal points. For example, in a crack-like flaw the terminal points appear much sharper in a sphere-like flaw, such as a gas cavity. Also, material strength may be adversely affected by flaw shape. A flaw having sharp points could establish a source of localized stress concentration. Spherical flaws affect material strength to a far lesser degree than do sharp pointed flaws. Specifications and reference standards usually stipulate that sharp pointed flaws, such as cracks, cold shuts, and so forth, are cause for rejection.

Material strength is also affected by flaw size. A metallic component of a given area is designed to carry a certain load plus a safety factor. Reducing this area by including a large flaw weakens the part and reduces the safety factor. Some flaws are often permitted in components because of these safety factors; in this case, the interpreter must determine the degree of tolerance or imperfection specified by the design engineer. Both flaw size and flaw shape should be considered carefully, since small flaws with sharp points can be just as bad as large flaws with no sharp points.

Another important consideration in flaw analysis is flaw location. Metallic components are subjected to numerous and varied forces during their effective service life. Generally, the distribution of these forces is not equal in the component or part, and certain critical areas may be rather highly stressed. The interpreter must pay special attention to these areas. Another aspect of flaw location is that certain types of discontinuities close to one another may potentially serve as a source of stress concentrations creating a situation that should be closely scrutinized.

An inclusion is a type of flaw which contains entrapped material. Such flaws may be of greater or lesser density than the item being radiographed. The foregoing discussions on flaw shape, size, and location apply equally to inclusions and to voids. In addition, a flaw containing foreign material could become a source of corrosion.

Radiation Hazards

Radiation from x-ray units and radioisotope sources is destructive to living tissue. It is universally recognized that in the use of such equipment, adequate protection must be provided. Personnel must keep outside the primary x-ray beam at all times.

Radiation produces changes in all matter through which it passes. This is also true of living tissue. When radiation strikes the molecules of the body, the effect may be no more than to dislodge a few electrons, but an excess of these changes could cause irreparable harm. When a complex organism is exposed to radiation, the degree of damage, if any, depends on which of its body cells have been changed.

Vital organs in the center of the body that are penetrated by radiation are likely to be harmed the most. The skin usually absorbs most of the radiation and reacts earliest to radiation.

If the whole body is exposed to a very large dose of radiation, death could result. In general, the type and severity of the pathological effects of radiation depend on the amount of radiation received at one time and the percentage of the total body exposed. Smaller doses of radiation could cause blood and intestinal disorders in a short period of time. The more delayed effects are leukemia and other cancers. Skin damage and loss of hair are also possible results of exposure to radiation.

Inspection of Composites

Composite structures should be inspected for delamination, which is separation of the various plies, debonding of the skin from the core, and evidence of moisture and corrosion. Previously discussed methods including ultrasonic, acoustic emission, and radiographic inspections may be used as recommended by the aircraft manufacturer. The simplest method used in testing composite structures is the tap test.

Tap Testing

Tap testing, also referred to as the ring test or coin test, is widely used as a quick evaluation of any accessible surface to detect the presence of delamination or debonding. The testing procedure consists of lightly tapping the surface with a light hammer (maximum weight of 2 ounces), a coin or other suitable device. The acoustic response or "ring" is compared to that of a known good area. A "flat" or "dead" response indicates an area of concern. Tap testing is limited to finding defects in relatively thin skins, less than 0.080" thick. On honeycomb structures, both sides need to be tested. Tap testing on only one side would not detect debonding on the opposite side.

Electrical Conductivity

Composite structures are not inherently electrically conductive. Some aircraft, because of their relatively low speed and type of use, are not affected by electrical issues. Manufacturers of other aircraft, such as high-speed high-performance jets, are required to utilize various methods of incorporating aluminum into their structures to make them conductive. The aluminum is imbedded within the plies of the lay-ups either as a

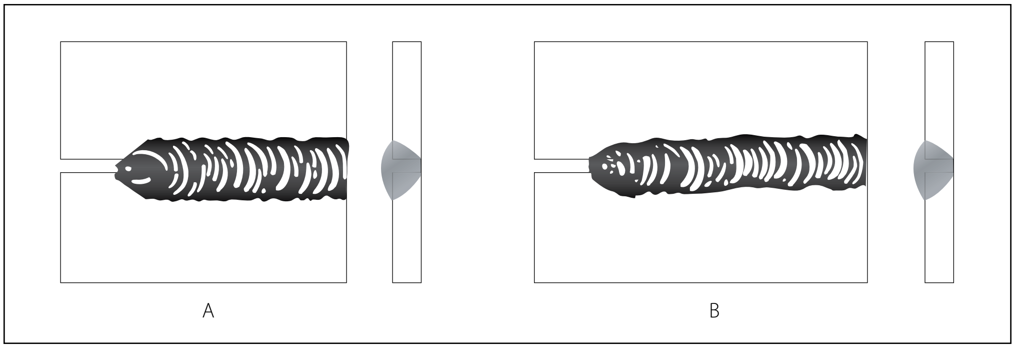

Figure 8-22. Examples of good welds.

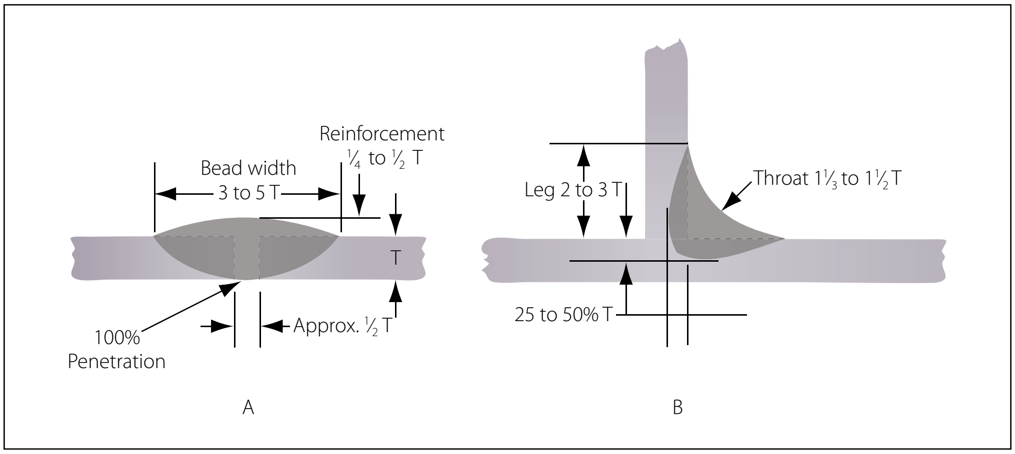

Figure 8-23. (A) Butt weld and (B) fillet weld, showing width and depth of bead.

thin wire mesh, screen, foil, or spray. When damaged sections of the structure are repaired, care must be taken to ensure that the conductive path be restored. Not only is it necessary to include the conductive material in the repair, but the continuity of the electrical path from the original conductive material to the replacement conductor and back to the original must be maintained. Electrical conductivity may be checked by use of an ohmmeter. Specific manufacturer's instructions must be carefully followed.

Inspection of Welds

A discussion of welds in this chapter will be confined to judging the quality of completed welds by visual means. Although the appearance of the completed weld is not a positive indication of quality, it provides a good clue about the care used in making it.

A properly designed joint weld is stronger than the base metal which it joins. The characteristics of a properly welded joint are discussed in the following paragraphs.

A good weld is uniform in width; the ripples are even and well feathered into the base metal, which shows no burn due to overheating. [Figure 8-22] The weld has good penetration and is free of gas pockets, porosity, or inclusions. The edges of the bead illustrated in Figure 8-22 (B) are not in a straight line, yet the weld is good since penetration is excellent.

Penetration is the depth of fusion in a weld. Thorough fusion is the most important characteristic contributing to a sound weld. Penetration is affected by the thickness of the material to be joined, the size of the filler rod, and how it is added. In a butt weld, the penetration should be 100 percent of the thickness of the base metal. On a fillet weld, the penetration requirements are 25 to 50 percent of the thickness of the base metal. The width and depth of bead for a butt weld and fillet weld are shown in Figure 8-23.

To assist further in determining the quality of a welded joint, several examples of incorrect welds are discussed in the following paragraphs.

The weld shown in Figure 8-24 (A) was made too rapidly. The long and pointed appearance of the

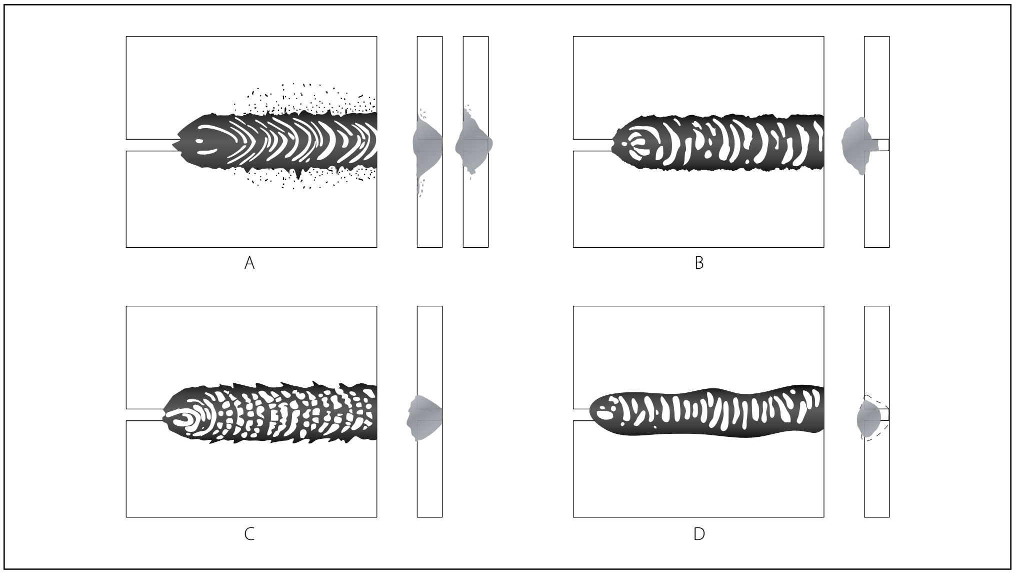

Figure 8-24. Examples of poor welds.

ripples was caused by an excessive amount of heat or an oxidizing flame. If the weld were cross-sectioned, it would probably disclose gas pockets, porosity, and slag inclusions.

Figure 8-24 (B) illustrates a weld that has improper penetration and cold laps caused by insufficient heat. It appears rough and irregular, and its edges are not feathered into the base metal.

The puddle has a tendency to boil during the welding operation if an excessive amount of acetylene is used. This often leaves slight bumps along the center and craters at the finish of the weld. Cross-checks are apparent if the body of the weld is sound. If the weld were cross-sectioned, pockets and porosity would be visible. Such a condition is shown in Figure 8-24 (C).

A bad weld with irregular edges and considerable variation in the depth of penetration is shown in D of Figure 8-24. It often has the appearance of a cold weld.