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ADVISORY CIRCULAR

MAINTENANCE INSPECTION NOTES FOR BOEING B-737 SERIES AIRCRAFT

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Initiated by: AFS-230

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SUBJECT: MAINTENANCE INSPECTION NOTES FOR BOEING B-737 SERIES AIRCRAFT

1. PURPOSE. This advisory circular provides maintenance inspection notes which can be used for the maintenance support program for certain structural parts of the B-737 series aircraft.

2. DESCRIPTION. Maintenance inspection matters on the wing and fuselage are reviewed with a view toward supplementing information currently available.

3. REFERENCES.

   a. Advisory Circular 20-61, Nondestructive Testing Techniques for Aircraft.

   b. Advisory Circular 65-9, Airframe and Powerplant Mechanics General Handbook.

   c. Advisory Circular 43.13-1, Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair.

   d. Defense Metals Information Center (DMIC) Report, S-25, dated 1 June 1968, Current Problems and Prevention of Fatigue.

   e. Advisory Circular 20-9, Personal Aircraft Inspection Handbook.

4. HOW TO GET THIS PUBLICATION.

   a. Order additional copies of this publication from:

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b. Identify this publication as: Advisory Circular No. 20-83, Maintenance Inspection Notes for Boeing B-737 Series Aircraft.

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1. INTRODUCTION. This advisory circular provides maintenance information which can be used, but is not required to be used, by mechanics, repair agencies, owners, and operators in developing maintenance programs, making improvements in existing programs, and conducting inspection and repairs on certain structural parts of Boeing B-737 airplanes. The material is based, in part, upon information made available through discussions with personnel who have maintained these types of airplanes for thousands of hours of time in service. The intent of the circular is to impart some of this knowledge to other interested persons so that it is not lost.

2. DESCRIPTION. This circular contains guidance material for performing maintenance on wing, fuselage, and empennage structure. The information has been derived from service experience. It does not comprise a full and complete maintenance program for the subject aircraft but should be considered as supplemental maintenance data. Included in the circular is a listing of selected maintenance difficulties which have been reported since 1968 by air carrier operators.

3. BACKGROUND.

* a. Used Aircraft. The Administrator realizes that several different types of transport aircraft are being phased out of service by some airlines and are being purchased by other operators who may not be familiar with the scope of required maintenance and the means which have been used to keep the aircraft in a safe condition. *

b. Maintenance "Know How." Since maintenance "know how" is not transferred with the aircraft, the new operator generally goes through a learning cycle before he is able to rapidly pinpoint the important/critical problem areas of the aircraft. In this respect, identification of known areas where structural problems have been experienced will help in the preparation of an initial maintenance program by a new operator. It also can serve as a guide to other operators who have not accumulated sufficient service experience to have knowledge of all the problem areas of the aircraft.

4. GENERAL DISCUSSION OF STRUCTURE SURVEILLANCE.

a. Manufacturer's Service Bulletins. The manufacturer has published service bulletins containing its recommendations concerning the inspection, repair, and modification of aircraft. Most of these bulletins cover known areas; however, some are predictive in nature and have been issued even though no fatigue damage has been identified in the fleet. Because of differences in structural configuration, most service bulletins apply only to certain aircraft. Effectivity is shown in each bulletin. Additional bulletins may be published by the manufacturer, and a service bulletin index is available from the manufacturer which is updated periodically.

b. Other Documentation. Further, the manufacturer has published the following documents to aid in maintaining the aircraft in serviceable condition:

* Maintenance Planning Document (D6-17594)
Maintenance Manual, (D6-series different for each operator)
Overhaul Manual, (D6-17370)
Structural Repair Manual, (D6-15565).
NDT Document (D6-7170) *

The above documents are updated from time to time by the manufacturer.

Structural Item Interim Advisories are published by the manufacturer to notify operators of newly found problems which may be of fleet-wide significance and may or may not be followed by service bulletins.

c. Maintenance Action. For adequate maintenance of the B-737 airplane structure, every operator should have in his possession and be conversant with the above documentation, including service bulletins applicable to his particular aircraft. He should also obtain complete service records from previous owners and become familiar with the structural history of his aircraft, including information on maintenance procedures followed, major repairs made, and preventive modifications and/or repair work incorporated per service bulletins. This is essential to carry out the follow-up procedures required, and to avoid unnecessary work where corrective action has already been taken.

(1) The new operator should contact the manufacturer regarding any areas requiring clarification.

(2) The operator should keep himself informed of new developments and arrange to be supplied with revised and new documentation by the manufacturer. Consultation with the manufacturer and/or more experienced operators should take place from time to time as necessary, to establish which service bulletins have structural significance and when they would best be incorporated.

(3) The maintenance program established by the new operator should reflect changes in environment and usage of the aircraft (e.g., shorter flights, intermittent use, etc.).

d. Airworthiness Directives. The material in this circular does not supersede requirements of airworthiness directives (AD's) issued by the FAA. Although manufacturers' service bulletins may be referred to in AD's, the bulletins do not supersede any requirements of the AD's.

e. Certification. Type certificate data sheet No. A16WE was issued 15 December 1967 for model 737-100 and 21 December 1967 for model 737-200 to the Boeing Company, Renton, Wa. The basis for certification was FAR 25, amendments 25-1 through 25-3, 25-7, 25-15; FAR 21;

FAR 1; and special conditions. (See type certificate data sheet A16WE for information relating to special conditions.) The latest revision of type certificate data sheet A16WE, at the time this document was published, was revision No. 5 dated 1 April 1972.

5. TYPE OF CONSTRUCTION. The aircraft structure can be classified into three major components; the fuselage, the wing, and the empennage. These components have been designed to provide maximum strength with minimum weight by providing multiple load paths so that the failure of any one structural element will not result in the failure of the complete structural component. The materials most commonly used throughout the structure are aluminum, steel, and magnesium alloys. In secondary structural areas and many flight control surfaces, aluminum and fiberglas honeycomb core material is extensively used.

a. The fuselage is a semimonocoque structure with the skin reinforced by circumferential frames and longitudinal stringers. It consists of four sections--body sections 41, 43, 46, and 48, with section 41 located between stations 178 and 360, section 43 between stations 360 and 540, section 46 between stations 540 and 1016, and section 48 between stations 1016 and 1217. The entire fuselage shell between stations 178 and 1016 is pressurized except for the nose gear well and the cutout for the center wing box and main landing gear well.

b. The wing is composed of a left wing box, center wing box, and a right wing box. The left and right wing boxes are cantilevered from the center wing box and the thickness and chord of each wing taper down toward the tip and sweep back from the center wing box. The surfaces of the wing boxes consist of upper and lower skin panels and front and rear spars. Throughout the wing boxes, the skin panels are reinforced by spanwise stringers and the spars are reinforced by vertical stiffeners.

(1) The left and right wing boxes are reinforced by chordwise ribs with the greatest portion of their enclosed volume sealed to serve as fuel tanks. The center wing box is reinforced by spanwise beams and contains bladder-type fuel cells. On each wing, the leading edge structure is cantilevered forward of the front spar. The trailing edge structure and control surfaces are cantilevered aft of the rear spar.

(2) Two flaps and three extendable slats are supported by the wing leading edge on each wing. Along the trailing edge of each wing an I/B and O/B flap, an aileron, and four spoilers are installed. The leading edge of each wing contains a pressure relief panel to alleviate pressures due to leaking or ruptured ducts associated with the engine. The pressure relief panel is designed to open at a pressure of one psi.

c. The empennage consists of a dorsal fin, a vertical fin, an adjustable horizontal stabilizer, a rudder, and elevators. The left and right horizontal stabilizers are removable from the center section truss located within the fuselage and have removable leading edges. The elevators are aluminum frame structures with leading and trailing edge spars, ribs, and a fiberglas skin. Each elevator contains three
* balance panels and a control tab. The rudder is a monospar aluminum alloy structure with chordwise ribs and honeycomb core fiberglas skin. *
It does not contain a tab.

6. AIRCRAFT STATION DIAGRAMS. The wing, fuselage, and empennage station diagrams included in this document were developed for the B-737 aircraft and are used as a general reference only. Several models of these aircraft were manufactured and have different station locator numbers based on the particular configuration. Since the defective areas generally apply to all models of aircraft, the referenced area can be compared with a similar area and locator on the appropriate station diagram for the particular model aircraft.

7. ABBREVIATIONS USED IN THIS DOCUMENT.

FAR	Federal Aviation Regulation
I/B	Inboard
L/H	Left Hand
MLG	Main Landing Gear
NLG	Nose Landing Gear
O/B	Outboard
P/N	Part Number
R/H	Right Hand
TAT	Total Aircraft Time
TSN	Time Since New
TSO	Time Since Overhaul

8. MAINTENANCE REPORTS. The following is a listing of selected maintenance difficulties experienced, representing examples of reports submitted by air carrier operators. This information may be useful in identifying structural problem areas. It should be noted that this is a partial list only and covers just a portion of time in the history of the B-737 series aircraft.

a. Fuselage.

* (1) During routine inspection, on two occasions a two-inch crack was found at the fuselage vertical pressure web above the wing rear spar below the cabin floor, 30" left of the cabin center line at station 663.75. TAT 4989 hours and 5113 hours. *

* (2) Routine inspection of the stub beam at the outboard lower chord, P/N 65-47995-2, disclosed a 4" spanwise crack just above the radius, R/H side of fuselage at station 559. TAT 5028 hours.

(3) During routine inspection, on two occasions skin cracks were found originating at the aft rivet hole of the L/H vortex generator at station 1114. TAT 3533 and 3634 hours.

(4) Routine service check disclosed a stringer cracked in two places at station 1115 L/H side. TAT 5462 hours. Associated with item (3) problem.

(5) Flight returned due to the L/H sliding window outer pane being cracked, P/N 5-71762-25. TSN 4130 hours. The outer pane has no structural significance.

(6) During routine inspection a 3" crack was found in the beam-to-frame attach clip, P/N 69-53023-2 in the R/H wheel well at station 663.75. TAT 6394 hours.

(7) An unscheduled landing was made due to a shattered outer pane of the L/H windshield. TAT 5195 hours. The outer pane has no structural significance.

(8) Routine inspection disclosed the lower wing to body attach angles cracked at left and right body station 540. *

b. Wing.

(1) A flight was interrupted due to loss of a 50" x 20" section of upper skin on the L/H I/B spoiler. TSN 1970 hours.

(2) During routine inspection, an 11" x 3-3/4" section of the R/H aileron lower skin was found delaminated from the honeycomb core at the leading edge. TSN 2270 hours.

(3) The abnormal appearance of a wing flap in flight resulted in an unscheduled landing. Inspection after landing disclosed a broken #2 flap fairing arm, P/N 65-68269-7.

(4) During flight-crew walkaround check, part of the top skin was found to be missing on the L/H I/B gound spoiler. TAT 5590 hours.

(5) A crew report of high frequency vibration inflight disclosed the cause to be loose top skin at the I/B end of #4 ground spoiler, P/N 65-46452-35. TAT 6221 hours.

(6) During routine inspection, three cracks were found in the skin of #2 engine nose cowl. The cracks were 2", 4½", and 5" in length. Nose cowl P/N 65-55750. Nose cowl TSN 4181 hours.

(7) During routine inspection, on three occasions, gusset plate P/N 65-45402-60 was found cracked, R/H side rear spar lower wing joint at WBL 70.85.

(8) Scheduled maintenance check found the #5 slat I/B attach fitting broken, P/N 69-40609-2. TAT 5374 hours.

(9) During scheduled inspections, the L/H and R/H I/B trailing edge flap ribs were found cracked at the O/B flanges at WBL 82.58 and WBL 117.10. Rib P/N's 69-40664-3, 65-50757-7, and 65-40663-5. TAT ranged from 4021 hours to 6948 hours.

(10) During scheduled inspection, the top skin of the R/H aileron was found to be delaminated at a skin joint at the front spar. Aileron TSN 5774 hours.

(11) Routine service check disclosed the #1 and #6 leading edge slat torsion tubes were cracked, tube P/N 69-50753-2. TAT 6310 hours.

(12) A 6" crack was found in #1 engine nose cowl, cowl TSN 4332 hours.

(13) Aircraft returned after leaving gate due to broken #4 leading edge flap arm P/N 69-37841-7. TAT 8379 hours.

(14) Crew report that the L/H trailing edge flap would not retract led to detection of a broken cable, P/N BACC13AP3D-772. TAT 6130 hours.

(15) During scheduled inspection, the #1 leading edge slat O/B torsion tube was found broken at the I/B end of the detent arm, tube P/N 65-55514-29. TAT 2888 hours.

(16) A crew report that #5 slat did not fully retract and #4 was cocked at an angle when flaps were extended disclosed that bracket P/N 69-40609-2 was broken at station 145.83.

(17) Crew reported that aircraft rolled to right when flaps were extended. Inspection found the R/H I/B aft flat cable tensioner terminal fitting and cable broken. TAT 5227 hours.

(18) During routine inspection, a crack was found in the L/H MLG beam O/B stabilizer link fitting, P/N 69-38823-5. TAT 3336 hours.

(19) Aircraft returned to ramp, crew reporting flaps inoperative. Inspection of the flap system revealed that the flap power unit assembly worm gear teeth were stripped. Flap power unit was replaced, aircraft released.

(20) There is a fleetwide corrosion maintenance program in operation to watch for corrosion and stress corrosion cracking on the upper and lower spar caps (both forward and rear spars) from RSS 450 outboard to about station 499. The upper cap is 7178-T6 material and is especially susceptible to stress corrosion cracking. The lower spar cap is 2024-T3 and is not quite so critical as far as stress corrosion is concerned. So far, only overseas operators have been severely affected.

* (21) During routine inspection, two cracks were detected in the web of BBL 41.0 lower left beam in the air conditioning bay. TAT 3117 hours.

(22) During scheduled inspections, the left and right wheel well gussets at station 663.75 were found cracked on four aircraft, gusset P/N's 65-45402-59 and -60. TAT ranged from 4869 hours to 6909 hours. *

c. <u>Empennage</u>.

(1) Routine inspection disclosed a cracked L/H horizontal stabilizer mounted vortex generator. The crack extended forward from the aft edge through four fastener holes. TAT 5462 hours.

(2) Five cracks were found in the skin at BS 1104. The cracks propagated from the upper fastener hold for R/H #2 vortex generator. TAT 2715 hours.

(3) A crew report of a rumble during letdown resulted in finding a portion of the R/H horizontal stabilizer vortex generator missing. TSO 1269 hours.

(4) During fleet campaign the L/H and R/H horizontal stabilizer vortex generators were found cracked at the 90° bend radius. TSN 1940 hours.

(5) On arrival, crew reported fuselage vibration of moderate intensity from 800 to 1200 CPS at all speeds above 240 knots. Inspectors found the elevator tab inboard hinge brackets, left and right, were worn resulting in excessive play. Hinge brackets were replaced and no vibration noted on test flight. MRR 70-082-11 dated 17 April 1970.

d. Main Landing Gear Problems.

(1) Extensive research and testing by Boeing have been performed to solve the MLG broken torque link and ensuing shimmy problem. * The MLG is responsive to the correct oil and air in the shock strut and proper tire pressure. Correct servicing results in improved service life. Service Bulletin 32-1064 describes the installation of a shimmy damper with increased stroke which provides a greater margin of resistance to shimmy. *

(2) During routine replacement of the main landing gear brake assemblies for normal wear, three shear studs (P/N 69-59091-1) were found failed and two cracked at the left inboard brake installation. Further investigation revealed one shear stud failed and one cracked at the left outboard brake installation. * All 18 replaced (MRR 70-135-047 dated 7 July 1970). Investigation revealed the studs had been installed with excessive torque. Affected operators have been advised of the correct torque by Service Bulletin 32-1068 R1. In addition, Service Bulletin 32-1094 describes the installation of new improved studs and bolts.*

APPENDIX 1. CORROSION

1. CAUSES OF CORROSION.

a. Metal corrosion is the deterioration of the metal by chemical or electrochemical attack. Corrosion can take place internally as well as on the surface of the metal. This deterioration may change the smooth surface, weaken the interior or damage or loosen adjacent parts.

b. Water or water vapor containing salt and combined with oxygen in the atmosphere produces main source of corrosion in aircraft. Thus, aircraft operating in a marine environment or in areas where the atmosphere contains industrial fumes which are corrosive are particularly susceptible to corrosive attacks. If unchecked, corrosion can cause eventual structural failure.

2. TYPES OF CORROSION. There are two general classifications of corrosion, direct chemical attack and electrochemical attack. In both types, the metal is converted into an oxide, hydroxide, or sulfate. The corrosion process involves the anode which is oxidized and cathode (or the corrosive agent) which is reduced.

a. Direct chemical attack. Corrosion by direct chemical attack results from direct exposure to caustic liquids or vapors. The anodic and cathodic change occurs at the same point. Direct chemical attack in aircraft structure deposits are caused by (1) spilled battery acid or fumes, (2) residual flux deposits from welds, and (3) trapped caustic cleaning fluids.

b. Electrochemical attack. An electrochemical attack is similar to the electrolytic reaction in electroplating or in a dry cell battery. The reaction requires a medium, like moisture, capable of conducting electricity. When a metal comes in contact with a corrosive agent (dissimilar metal) and is connected by a liquid path, the metal decays or corrodes. The electrochemical attack is responsible for most forms of corrosion on aircraft structure.

3. FORMS OF CORROSION. There are many forms of corrosion which depend on the metal involved, size, shape, atmospheric conditions and corrosion producing agents.

a. Surface corrosion. This may be caused by either direct chemical or electrochemical attack. Surface corrosion appears as a general roughening or pitting of the surface of a metal accompanied by a powdery deposit of corrosion products.

b. Dissimilar metal corrosion. Extensive pitting damage may result from contact between dissimilar metal parts in the presence of a conductor. A galvanic action like electroplating occurs at points of contact when insulation has broken down or was omitted.

c. Intergranular corrosion. The grain boundaries of an alloy are attacked by this type of corrosion. Intergranular corrosion may exist without visible surface evidence. Severe intergranular corrosion may sometimes cause the surface of a metal to "exfoliate." This is a flaking of the metal at the surface caused by pressure of corrosion residual product buildup.

d. Stress corrosion. This type corrosion occurs as the result of the combined effect of tensile stresses and corrosive environment. Stress corrosion is found in most metals. However, it is a particular characteristic of aluminum, certain stainless steels, and high strength steels.

e. Fretting corrosion. This occurs when two mating surfaces are subject to relative motion although normally at rest with respect to each other. It is characterized by surface pitting and generation of finely divided debris.

4. FACTORS AFFECTING CORROSION. Many factors affect the speed, cause, type, and seriousness of metal corrosion which include:

a. Climate.

b. Size and type of metal.

c. Foreign material.

5. CORROSION PREVENTION. Corrosion-preventive maintenance includes:

a. An adequate cleaning.

b. Thorough periodic lubrication.

c. Detailed inspection for corrosion and failure of protective systems.

d. Prompt treatment of corrosion and touchup of damaged paint areas.

e. Keeping drainholes free of obstruction.

f. Daily wipedown of exposed critical areas.

g. Sealing of aircraft against water during foul weather and proper ventilation on warm, sunny days.

h. Making maximum use of protective covers on parked aircraft.

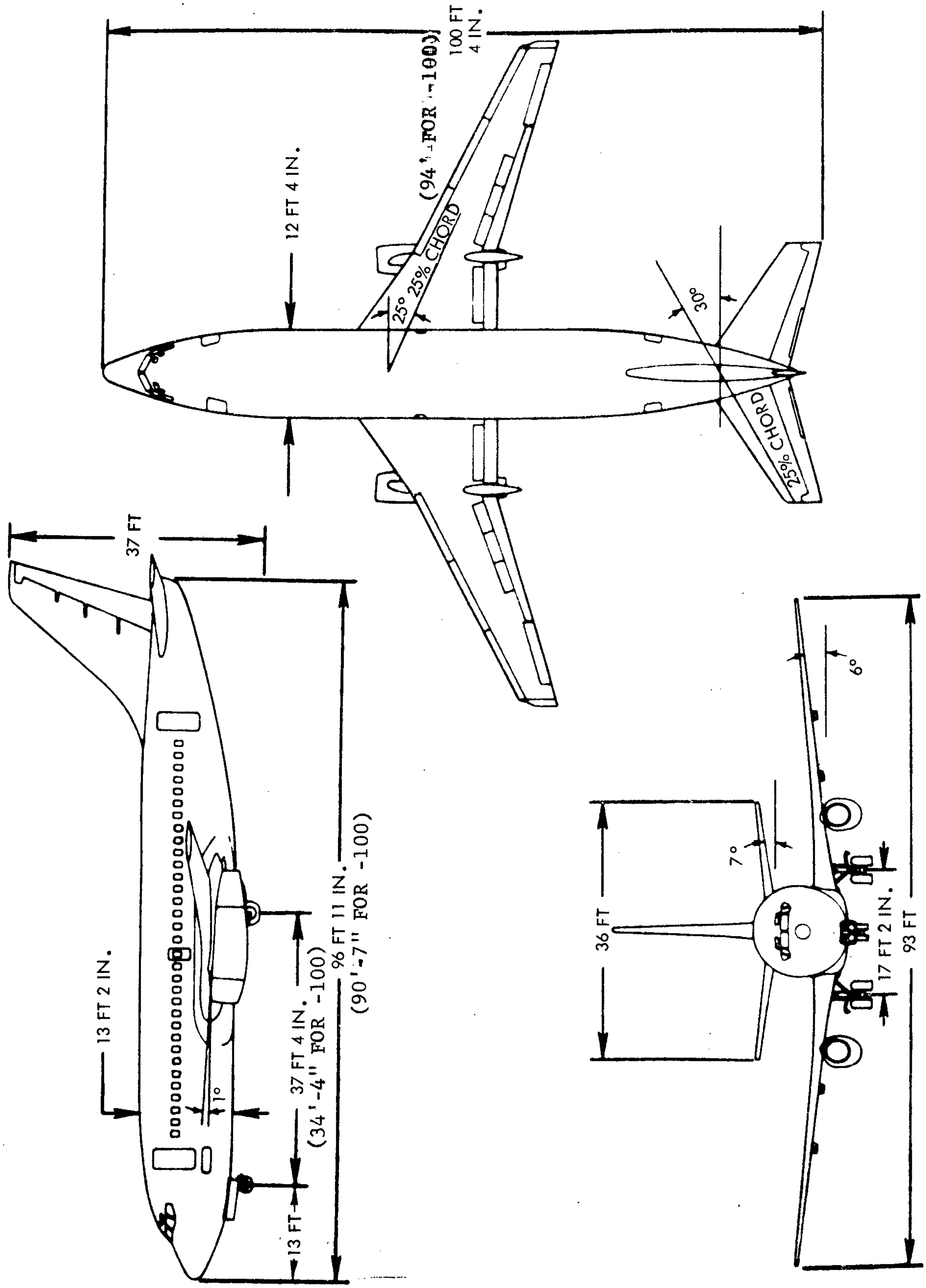


Figure 1. Principal Dimensions (-200)

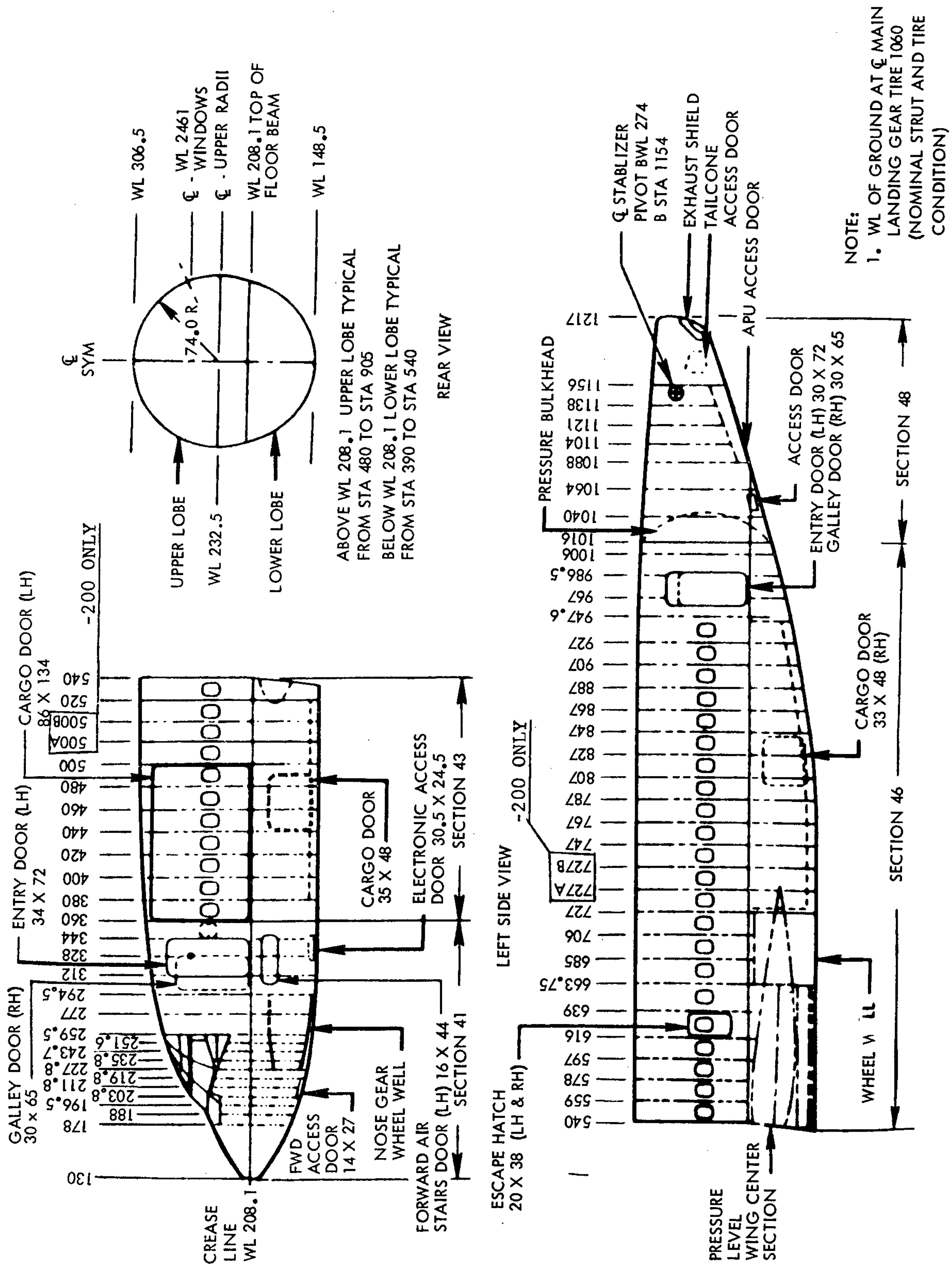
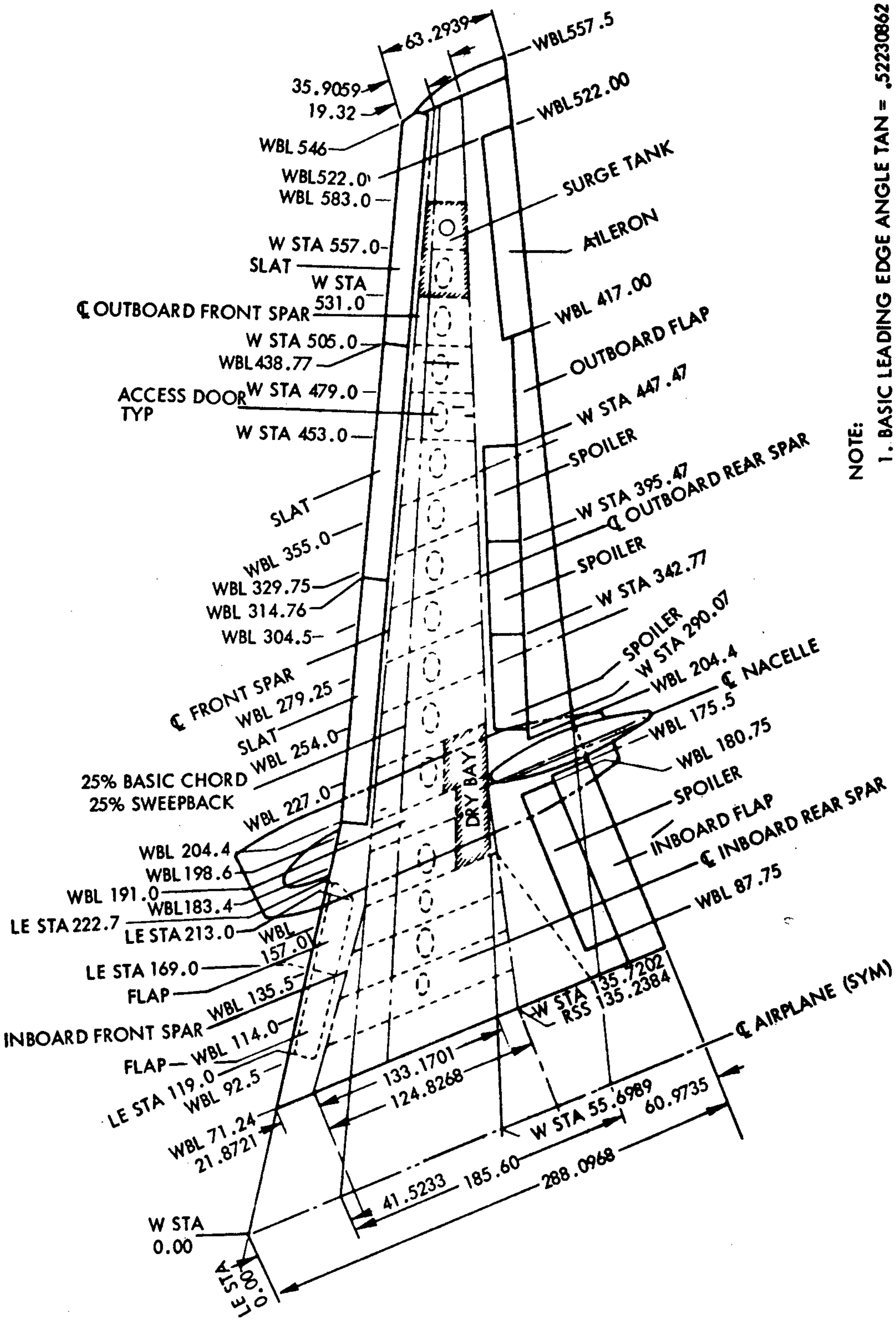
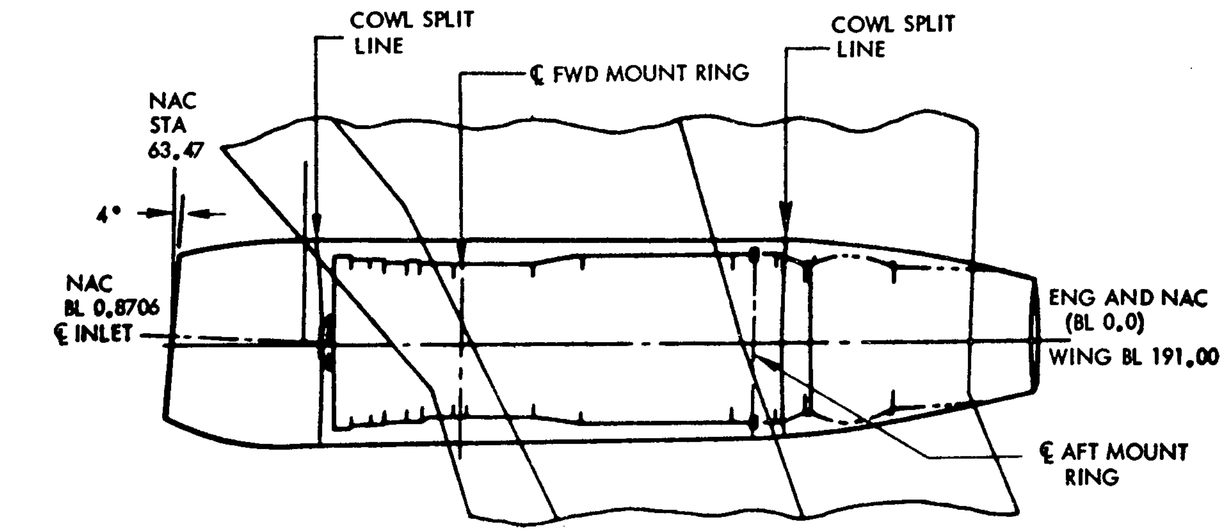


Figure 2. Body Station Diagram



NOTE:
1. BASIC LEADING EDGE ANGLE TAN = .52230862
2. SEMI SPAN 46.50 FEET

Figure 3. Wing Station Diagram



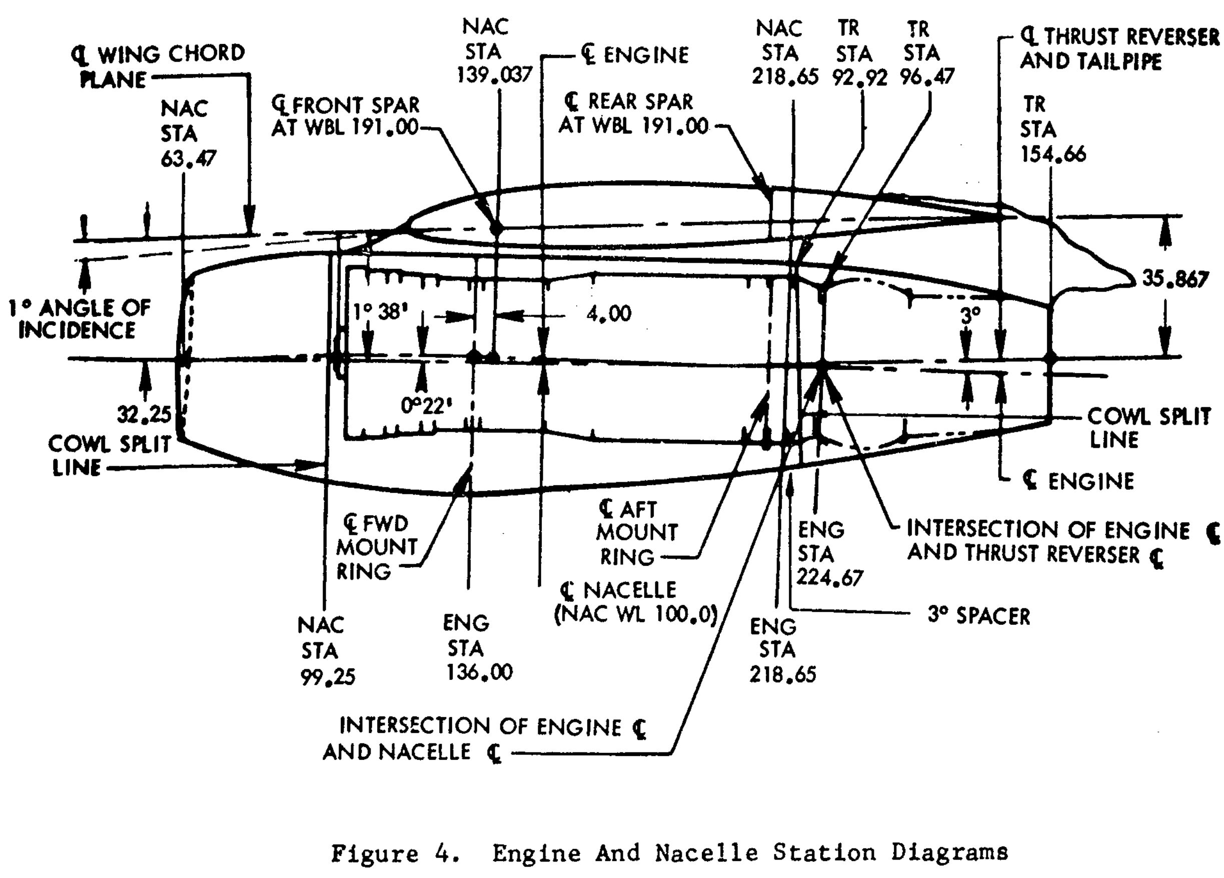


Figure 4. Engine And Nacelle Station Diagrams

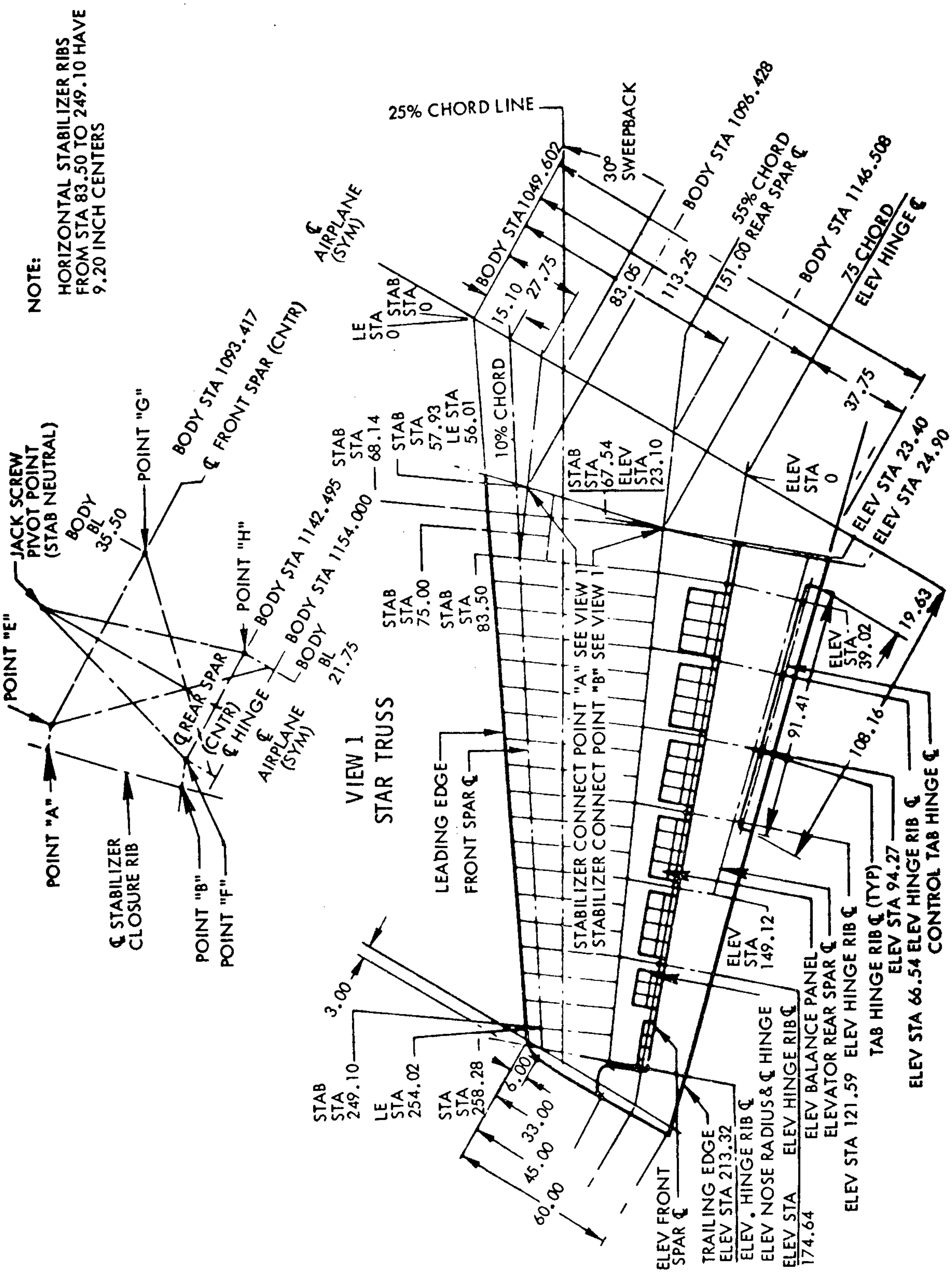


Figure 5. Horizontal Stabilizer and Elevator Station Diagrams

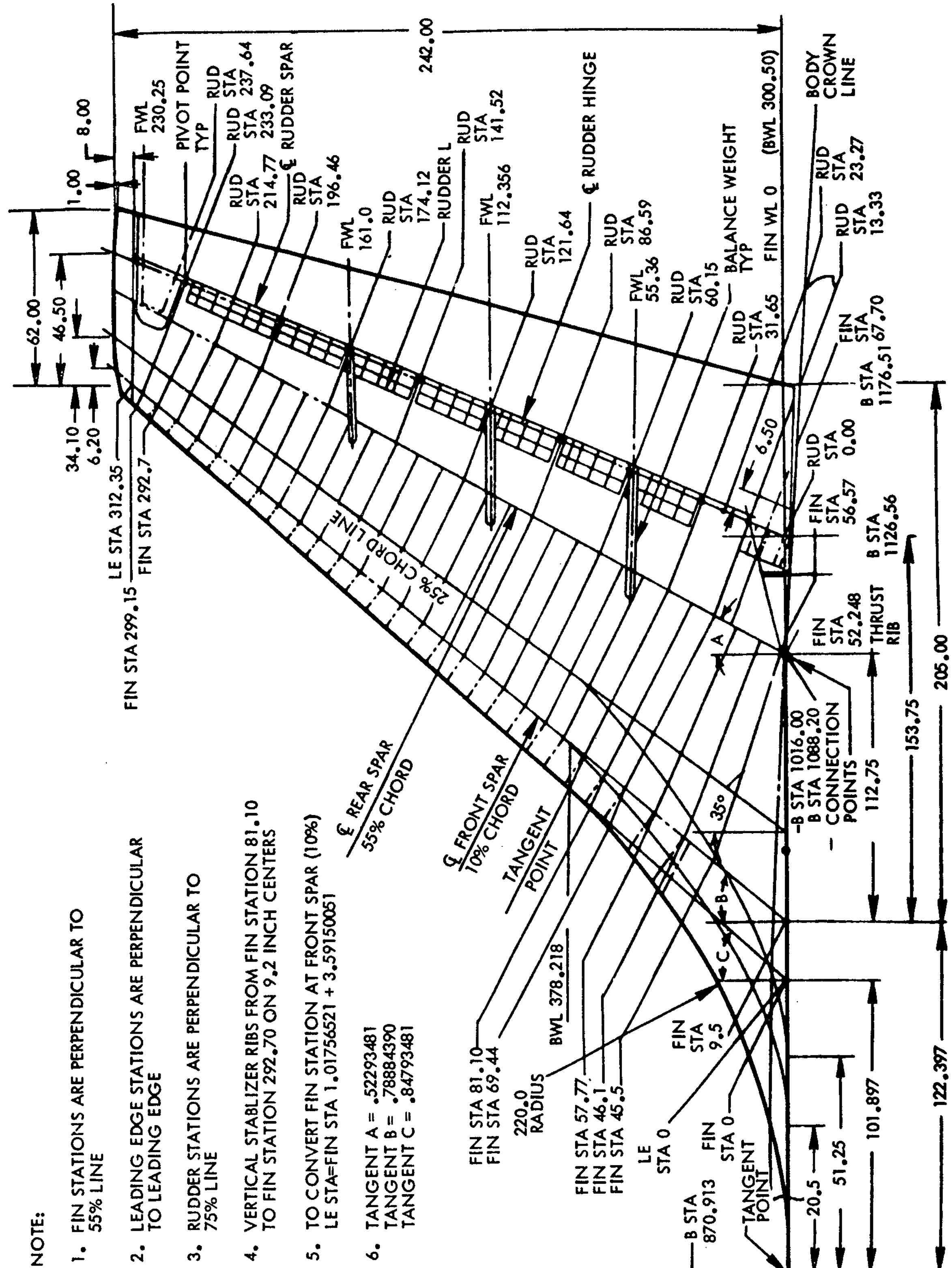


Figure 6. Vertical Stabilizer and Rudder Station Diagrams

APPENDIX 3. NONDESTRUCTIVE TESTING

1. MAINTENANCE TOOL. Simply stated nondestructive testing (NDT) is a tool for performing maintenance inspections such as X-ray, ultrasonic, * magnetic particles, eddy current, dye penetrant, and visual with or without magnification. *

a. Maintenance Inspection. NDT permits maintenance inspection without removing components from aircraft or tearing down complex assemblies. Defects in various aircraft systems which would escape detection through normal visual inspection will be identified by NDT.

b. Training Required. Special NDT training is desirable to make sure that the technician is capable of operating the equipment and interpreting the results. Also, many States require that an X-ray technician have an approved certificate for use of X-ray in industrial applications. This is to minimize improper use with attendant health hazard of X-ray equipment.

2. METHODS AND APPROACHES FOR DAMAGE DETECTION. Information on the application of NDT methods for the detection of fatigue damage is scattered through literature on metal fatigue and literature on NDT. Few publications deal with this problem specifically. Some publications are limited to laboratory investigations, and the NDT application is conducted under controlled laboratory conditions. Such investigations contribute considerably to available knowledge and provide new or improved NDT methods for field use. However, there is a great difference between what can be done in the laboratory and what can be used in practical applications under field service conditions.

3. NDT METHOD IN FIELD AND SERVICE USE. Most of the NDT methods that are used under field and service conditions are those capable of detecting fatigue cracks of various sizes. These methods are described in books on the subject of nondestructive testing and other publications such as reports, technical papers, and magazine articles. The NDT methods most commonly used in the field and service for fatigue crack detection follow.

4. VISUAL INSPECTION. Visual inspection is the oldest, simplest, cheapest, and most widely used of all NDT methods. The basic principal used in visual inspection is to illuminate the object and examine the surface with the eye.

a. The surface should be adequately cleaned before being inspected. Visual inspection for detection of fatigue cracks can be improved by aids such as mirrors, lenses, microscopes, periscopes, and telescopes. These devices compensate for limitations of the human eye. Boroscopes permit direct visual inspection of the interior of hollow tubes, chambers, and other internal surfaces.

b. The capability of visual inspection to detect a fatigue crack depends on many factors such as the size and location of the crack, the illumination used, optical aids employed, and skill of the inspector. It is often difficult to detect even a relatively large fatigue crack that is located, for example, at the corner of a groove or that coincides with a machining mark. There are, of course, also limitations on the size of cracks that can be detected by visual inspection, depending on optical aids employed.

5. LIQUID PENETRANT. The liquid penetrant is one of the oldest methods of nondestructive testing and is capable of detecting cracks that may be impossible to find with the most careful visual inspection because either they are too small or because they are difficult to detect due to their location. The principle involves applying to the part surface a liquid penetrant having a low-surface tension and low viscosity. When used on a clean surface that the liquid will wet, the liquid is drawn into the cracks by capillary action. The presence of the liquid in the cracks is revealed when, after wiping the excess liquid from the surface, a developer is applied that acts like a blotter and draws the liquid out.

a. There are two types of liquid penetrants in general use. One contains a dye which usually gives a good color contrast against the selected developer; the other contains dissolved flourescent material, which makes it readily visible when viewed under a "black" (ultraviolet) light.

b. Liquid penetrant inspection is inexpensive and readily applicable to field use. The surface must be cleaned before inspection and also afterwards to remove the developer.

6. MAGNETIC METHODS. Magnetic inspections are used to detect surface or near surface discontinuities in ferromagnetic materials, and they are well suited for the detection of fatigue cracks.

a. The principle employed here is that once a magnetic field is induced in a material, any cracks and flaws that are present, will perturb or distort that magnetic field. These methods are most sensitive when the crack orientation and the magnetic field direction are perpindicular to each other. When they are parallel, the crack will not be detected.

b. The magnetic particle method is the most frequently used. It consists of three basic steps:

(1) Establishment of the magnetic field in the part to be inspected.

(2) Application of magnetic particles to the surfaces of the part.

(3) Visual examination of the surfaces for indications of fatigue cracks. These indications are provided by the particles being

(3) Visual examination of the surfaces for indications of fatigue cracks. These indications are provided by the particles being attracted to the locations of the cracks (or other defects) due to local variations in the magnetic field that are produced.

c. Two classes of magnetic particles are available. The wet method particles use a liquid vehicle; the dry method particles are borne by air. These particles are usually:

(1) Colored to give contrast with the surface being inspected, or

(2) Coated with fluorescent material to make them readily visible under black light. Parts inspected by magnetic particle methods must be cleaned.

7. RADIOGRAPHY. Radiography is a method of nondestructive testing which uses X-ray, gamma, beta, or neutron radiation. It is based on the ability of these radioactive sources to penetrate materials. The intensity of the penetrating radioactivity is modified by passage through materials and by defects in the material. These intensity changes are recorded on film as areas of varying density (or darkness) which permits distinguishing flaws and cracks. Obviously, maximum sensitivity occurs when the cracks are oriented such that its longest dimension is parallel to the direction of radiation.

a. X-ray radiography has two main advantages; (1) versatility, and (2) sensitivity. The X-ray energy source can be easily adjusted for variations in thickness. It is also adaptable to fluoroscopy and television systems.

b. The advantages of gamma radiography are; (1) portability, and (2) a relatively low cost. Portability comes from the fact that the source is small. This permits its effective use in the field particularly in remote areas. One of the difficulties with the gamma radioactive source is that the source cannot be varied or turned off so that safety precautions must be observed at all times. (X-ray constitutes a health hazard only during operation of the X-ray equipment).

c. Conventional radiography is firmly established and reasonably easy to understand. One of the original drawbacks was the long time involved in the developing and processing of film. This has been overcome by modern automatic film processing techniques.

d. Interpretation of the processed film is the most important phase of radiography. Adequate tools such as a film illuminator lens and good working conditions should be available to assist the interpreter in detecting cracks in the part displayed on the film.

8. ULTRASONICS. Ultrasonic methods have received wide acceptance in the aviation industry and are particularly useful for determining the integrity of a member of a structure. Basically, sound energy above the audible range is transmitted into a part, and a signal is received and analyzed. The ultrasonic wave is transmitted and received through transducers, which are placed upon the part to be inspected. The transducer must be properly coupled to the part and is the most critical aspect of the inspection. Good coupling can be achieved by using liquids at the transducer part interface.

a. The ultrasonic wave (or beam) may be evaluated in terms of either through transmission or reflection. The receiving transducer may be a separate unit (through transmission) or it may be the same transducer that sent the signal (reflection and resonance). For crack detection, the reflection technique is most commonly used. It permits the determination of the location of the crack wherever it might be within the part and only one transducer on one side of the part is needed. When ultrasonic wave (pulse) is sent into the part, a discontinuity (e.g. a crack) in its path on which it impinges will both absorb and reflect energy. A defect can be recognized by the relative time for return of the reflected energy to the transducer.

b. The ultrasonic methods now available are rapid, economical, sensitive, and can have good accuracy for determining crack extent and position. Equipment is light and portable so that on-site inspections are possible. There are conditions which can limit the usefulness of ultrasonic inspections. These include unfavorable part geometry (such as complexity, contour, and size) orientation of the cracks, and misleading responses which may occasionally be obtained. Also, ultrasonic inspection, as presently practiced, depends upon experience, skill, and judgment of the inspector. He must interpret the crack size and location by the indirect evidence presented by the electronic equipment (oscilloscope). He must be able to distinguish between significant signals and spurious ones.

9. EDDY CURRENT. The eddy current method is a comparatively recent nondestructive testing technique. It is being frequently used for nonmagnetic materials. (When used for magnetic materials, it requires more complex systems). The principle involved is simple. A coil that is carrying a high-frequency alternating current is brought near an electrical conductor and eddy currents are generated in the conductor. The eddy (or induced) current creates a magnetic field. Flaws, cracks, etc., cause resistance changes within the part. This affects the induced currents, and thus, the magnetic field produced by them. Detection and measurement of the magnetic field form the basis of the nondestructive testing.

a. Two types of coils are in common use. One is a circumferential coil through which a part passes. The second is called a probe coil which is placed on the surface of the part to be inspected. Each type coil can be made in a number of designs, depending on the application.

b. Eddy current instruments have various degrees of versatility. Many are portable. Once proven for a specific application, the inspection process is very rapid. Eddy current methods have been used very successfully for fatigue crack detection. However, eddy current methods are sensitive to many variables that influence the results obtained. Also, signals obtained are sometimes of a comparative nature, and reference standards are needed for interpretation.

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