AIRFRAME SYMMETRY & ALIGNMENT CHECKS

Plane of symmetry

Line perpendicular to plane of symmetry

Dihedral angle

1/12/2016
Airframe Symmetry – describes Methods used to make alignments and symmetry checks for:

a. Complete Airframe for Symmetry
b. Fuselage for Twist and Bending;

01/12/2016
Aircraft Symmetry & Alignment Checks

- A misaligned condition can seriously affect the flying quality of the a/c.
- Misalignment – may not be apparent by casual observation and may only be found by symmetry and alignment checks using instruments.

Checks should normally be done After:
- Any major structural repair, or
- The Aircraft has been subjected to severe conditions, such as a heavy landing, extreme turbulence, overspeeding, or violent maneuvers.
Symmetry and Alignment Checks should also be done if any of the following conditions are observed:

- Unusual flight characteristics;
- Parallel biased waves of structural plating;
- Wrinkling or buckling of structural plating;
- Loose or sheared fasteners;
- Areas of badly fitting access and inspection panels.
Symmetry and Alignment Checks – involve the measuring of Elevations and Distances between reference points on the aircraft.

These are checked against the established dimensions included in this topic.

Dimensions obtained should be recorded on record sheets.
Aircraft Symmetry & Alignment Checks

- The checks – **must be done in still air with a levelled aircraft on a smooth hard surface floor**.
- The aircraft **must be protected from wind**;
- If air is moving over any relevant surface then inaccurate measurement will result.
- Expansion or Contraction of the aircraft due to temperature change can also cause variations in measurements,
- The checks – **should ideally be done in an enclosed shaded area and the a/c allow to assume ambient temperature**.
Aircraft Symmetry & Alignment Checks

• All fuel tanks must be fully drained, and any cargo removed.
• Any weight of fuel in the wings will cause sufficient wing deflection to produce error in dimensions.

✓ The aircraft must be set up as specified for each operation.
Aircraft Rigging:

- AIRFRAME RIGGING,

  and

  ▪ Flight Control Systems (& Surfaces)
Kata “RIGGING” atau “(penataan /penyetelan)” dapat diterapkan pada:

– Control System (Sistim Kendali/kemudi) Rigging, dan
– Airframe (Rangka pesawat) Rigging.

CONTROL SYSTEM RIGGING – adalah proses menata/pengaturan sistim lengkap supaya sistim tsb. bekerja dengan benar.
AIRFRAME RIGGING

- AIRFRAME RIGGING – adalah proses untuk memastikan bagian-bagian utama dari rangka pesawat (seperti: wing, tailplane / horizontal stabilizer, fin / vertical stabilizer, dsb.) terletak di tempatnya yang benar, relatif satu sama lainnya, dan tidak distorsi/ menyimpang.

- Untuk kebanyakan pemeriksaan /checks – pesawat udara harus diletakkan dalam posisi rigging (level).
• **THE RIGGING POSITION** – is obtained by jacking the aircraft and using a spirit level, or plumb bobs i.a.w the AMM (Aircraft Maintenance Manuals).

• **POSISSI/LETAK RIGGING** – didapat dengan mendongkrak pesawat terbang dan menggunakan suatu spirit level dan plumb bob, sesuai dengan AMM.
The word “RIGGING” or “(adjustment)” can be applied to:

– Control System Rigging and
– Airframe Rigging. (we’ll concentrate on A/F Rigging).

CONTROL SYSTEM RIGGING: – is a process of setting up the complete system so that it works correctly.
• **AIRFRAME RIGGING:** – is the process of ensuring the main parts/components of the airframe (wing, tailplane, fin, etc) are in their correct position relative to each other, and are not distorted.

• **THE RIGGING POSITION** – is obtained by jacking the aircraft and using a spirit level, or plumb bobs i.a.w the AMM (Aircraft Maintenance Manuals).
The **most important source** of rigging specifications is:

**Type Certification Data Sheets (TCDS) (or Aircraft Specifications)**

- Is most accurate for details
- Includes:
  - Leveling means
  - Control surface travel
  - Weight and balance information
Rigging Specifications

Figure 15-3. An Airplane Type Certificate Data Sheet.
Oil capacity
(wet sump)
Max. operating limit

Control surface movements

<table>
<thead>
<tr>
<th></th>
<th>Maximum</th>
<th>Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wing flaps</td>
<td>30°</td>
<td>15°</td>
</tr>
<tr>
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<td>25°</td>
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<tr>
<td>Aileron tab anti-servo</td>
<td>12°</td>
<td>7°</td>
</tr>
<tr>
<td>Elevator</td>
<td>17°</td>
<td>15°</td>
</tr>
<tr>
<td>Elevator tab (L.H. only)</td>
<td>10°</td>
<td></td>
</tr>
<tr>
<td>Elevator tab servo</td>
<td>6°</td>
<td></td>
</tr>
<tr>
<td>Rudder</td>
<td>Right 33°</td>
<td>Left 28°</td>
</tr>
<tr>
<td>Rudder tab</td>
<td>Right 26°</td>
<td>Left 26°</td>
</tr>
</tbody>
</table>

Serial Nos. eligible

- Model 60: P-3 thru P-126 (except P-127)
- Model A60: P-123, P-127 and up (see NOTE 3)

Datum

- Located 100 in. forward of front pressure bulkhead

Leveling means

- Drop plumb line between leveling screws in cabin door frame rear edge

Certification basis

- Part 23 of the Federal Aviation Regulations effective February 1, 1963 as amended by 1, 2, 3, and 12; and Special Conditions dated May 16, 1967, forwarded with FAA letter dated June 1, 1967; approved for flight into
Rigging Specifications

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

TYPE CERTIFICATE DATA SHEET NO. A12CE

This data sheet which is part of type certificate No. A12CE 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
Beech Aircraft Corporation
Wichita, Kansas 67201

1. Model 60, 4 or 6 PCLM (Normal Category), Approved February 1, 1968
Model A60-4 or 6 PCLM (Normal Category), Approved January 30, 1970

Engines
Lycoming T10-541-E1A4 or T10-541-E1C4 (2 of either or 1 of each)

Fuel
100/130 minimum grade aviation gasoline

Engine limits
For all operations, 2900 r.p.m. (380 b. hp.)

Propeller and propeller limits
(a) Two (in any combination) Hartzell three-blade propellers
Diameter: 74 in. (Normal) Minimum allowable for repair 73 1/2 in.
(No further reduction permitted)
Pitch settings at 30 in. s/a:
low 14", high 81.7"
HC-F 3 YR-2/FC7479-2R
or HC-F 3 YR-2/FC7497B-2R
or HC-F 3 YR-2/FC7497B-2R
or HC-F 3 YR-2/FC7497B-2R
(b) Beech 60-389000-3 governor

Airspeed limits
Never exceed 235 knots
Maximum structural cruising 208 knots
Maneuvering 161 knots
Maximum flap extension speed
Approach position 15° 175 knots
Full down position 30° 135 knots
Landing gear extended 174 knots
Landing gear operating 174 knots

C.G. range (landing gear extended)
(+134.2) to (+139.2) at 6725 lb.
(+128.0) to (+139.2) at 5150 lb. or less
Straight line variation between points given
Moment change due to retracting landing gear (+857 in.-lb.)

Figure 15-3. An Airplane Type Certificate Data Sheet.
The Aircraft can be PUT INTO RIGGING POSITION (LEVEL) BY the:

1. Spirit Level method (or clinometer).
2. Plumb Bob and a Transit methods, or
3. A Theodolite and Sighting Rods.
4. Use of the aircraft’s FMS (Flight Management System). (e.g. Use for determining Airbus aircraft attitude).
The Aircraft can be PUT INTO RIGGING POSITION (LEVEL) BY— (cont’d) :

- The particular equipment to use is usually specified in the Manufacturer’s Manuals.
- When rigging an aircraft, always follow the procedures and methods specified by the aircraft’s manufacturer. (the Manufacturer’s Manuals).
Tanya: Apa itu POSISI RIGGING (RIGGING POSITION)?

Jawab: Posisi /letak dimana Garis Datum Lateral dan Longitudinal adalah Mendatar (Horizontal atau Level).
Q: **DEFINISI-KAN GARIS DATUM LATERAL DAN LONGITUDINAL.**

A: Garis khayal ditarik saling tegak-lurus dan melalui titik berat (C.G) pesawat.
➢ **LONGITUDINAL DATUM LINE** – ditarik dari depan sampai belakang fuselage.

➢ **LATERAL DATUM LINE** – ADALAH:

   ▪ Sebuah garis yang ditarik dari ujung wing (wing tip) – ke – wing tip, Atau
   ▪ Parallel /sejajar terhadap garis yang menjulur dari wing-tip ke wing-tip.
Q: WHAT IS THE Rigging Position?
A: It is where the Lateral and Longitudinal Datum Lines are Horizontal (Level).

Q: DEFINE THE LATERAL AND LONGITUDINAL DATUM LINES.
A: They are imaginary lines running at the right angles to each other and passing through the C.G of the aircraft.

- The Longitudinal Datum Line runs fore and aft along the fuselage.
- The Lateral Datum Line - Is:
  - A line runs From wing-tip to wing-tip, Or
  - Parallel to a line running from wing-tip to wing-tip.
Longitudinal and Lateral Datum Lines
Datum Lines and Datum Points

Fig. 28 DATUM LINES AND DATUM POINTS
Aircraft Leveling Set-up:

Theodolite – dipasang 2 meter didepan hidung pesawat (nose fuselage);
Theodolite ditempatkan di 4 (empat) tempat, y.i.:
• Dua (2) Didepan wing kiri & kanan;
• Dua (2) Dibelakang fuselage, di pangkal Horizontal Stabilizer
THE RIGGING POSITION – is obtained by:

Jacking the aircraft and using a Spirit Level, or Plumb Bobs i.a.w the AMM.

FIGURE : JACKING and TRESTLING POINTS
BEFORE CHECKING the POSITION or ANGLE of the Main Structural Components:

- The Aircraft Fuselage should be Leveled, (put into Rigging position).

- Rigging & alignment checks Should be performed, when aircraft:
  - Inside a closed hangar to minimize wind currents
  - If it must be outside, positioned the aircraft’s nose into the wind
BEFORE JACKING the Aircraft:

- **THE WEIGHT & LOADING** of the Aircraft should be **exactly** as described in the Manufacturer’s Manual.

- In all cases, **the a/c should Not be Jacked** until it is ensured that **the Max. Jacking Weight** (if any) specified by the manufacturer, **is not exceeded**.

- Except, Dihedral and Incidence Angles of modern conventional A/C cannot be adjusted.
Jacking point

Figure 11-41. Jacking a complete aircraft.

Wing jack pad assembly
Figure 3-4. Airbus A-320 being jacked.
(1) Spirit Level Method:

1. Refer to the AMM and configure the aircraft for jacking.
2. Jack the aircraft until the wheels are clear of the ground and the aircraft is approximately in rigging position.
3. Place a straight edge on the lateral datum points and adjust one of the main jacks until the spirit level on the straight edge reads level.
4. Place a straight edge on the longitudinal datum points and adjust the nose jack on the tail trestle until the spirit level on the straight edge reads level.
5. Recheck the lateral level.
6. If the lateral level is incorrect, repeat points 3 to 5 above.
(1) Spirit Level Method – (cont’d):

- Main Jack
- Nose Jack

Fig. 28 DATUM LINES AND DATUM POINTS
Notes:

1) In some aircraft spirit levels may be fixed in the structure, but the procedure is similar to that outlined above.

2) For jacking procedures refer to the book entitle Aircraft Handling.
(1) Spirit Level or Clinometer Method

• Aircraft that use the Spirit Level Method – have leveling lugs either built in to the structure or provisions of mounting them on the structure.

• The leveling lugs are usually in the nose-wheel well. Spirit leveling lugs are shown in Figure 9-44.

NOTE: The leveling lugs should be inspected for possible damage or misalignment prior to leveling the aircraft.

• In the event of damage to the leveling lugs, the repaired lugs must be calibrated by cross-reference with the Transit Leveling Method.
Figure 9-44.—Spirit leveling.
Leveling means – built in to the structure

Figure 6-10. The leveling means for an aircraft are specified in its Type Certificate Data Sheets.
(2) Plumb Bob Method:

1. Proceed as in items 1 and 2 above (spirit level method).

2. Attach a Plum Bob to the correct part of the airframe (AMM) and note its hanging position in relation to a star or grid-plate (Fig.2-67), which is fixed on the structure beneath it.

3. Adjust the approximate jack/trestle to bring the Plum Bob to the central point of the grid-plate.
Airframe Rigging – POSITION / CHECKS

• Plumb-Bob

• Clinometer or Inclinometer

Sitometer Kern 2 (Military model)
Figure 2-67: TIPICAL STAR OR GRID PLATE

Scale reading one unit per inch of jack movement.
Rigging and Alignment

• **The Grid Plate** (Fig. 2-67) – is a permanent fixture installed on the aircraft floor or supporting structure.

• When the a/c is to be leveled, a Plumb Bob is suspended on a predetermined position in the ceiling of the aircraft over the grid plate.

• The adjustment to the jack necessary to level the a/c are indicated on the grid scale.

• **The a/c is level when** the Plumb Bob is suspended over the center point of the grid.
Plumb bob and Datum Plate Leveling.

Figure 9-45.—Plumb bob and datum plate leveling.
Transit Method

Transit - The Transit Method is the most accurate.

- Transit Leveling is accomplished by sighting specified points on the aircraft.
- Two longitudinal and two lateral points are used for this method. The reference points are sighted through a surveyor’s transit.
- Figure 9-43 illustrates longitudinal and lateral leveling of an aircraft using the transit method.
Figure 9-43.—
Transit leveling.
(4) Use of the aircraft’s FMS (Flight Management System). (e.g. Use for determining Airbus aircraft attitude)

**Note:**
The Longitudinal & Lateral Clinometers – fitted to the structure as shown in Fig. 30
Airframe Symmetry:

✓ Methods of Alignment and
  ▪ Symmetry Checks
The purpose of this section is –

• To explain the **Methods of checking the relative Alignment and Adjustment** of an aircraft’s main structural components.

• When rigging an aircraft, always follow the procedures and methods specified by the aircraft manufacturer.

**Caution:**

• Normally, **rigging and alignment check** should always be performed **inside the hangar**.

• If this cannot be avoided – the a/c should be positioned with the **nose into the wind**.
RIGGING CHECKS – STRUCTURAL ALIGNMENT:

- The Position or Angle of the Main Structural Components is related to:
  - **Longitudinal Datum Line** – is an imaginary line parallel to the aircraft center-line, and
  - **Lateral Datum Line** – is an imaginary line parallel to a line joining the wing tips.

- **Before Checking the Position or Angle of Main Components, the Aircraft should be Leveled.**
Datum (Reference Datum) – is:

- An imaginary vertical plane or line from which all measurements of arm are taken.
- The datum is established by the manufacturer.
- Once the datum has been selected, all moment arms and the location of CG range are measured from this point.
Longitudinal and Lateral Datum Lines

- Rudder
- Longitudinal axis
- Elevator
- Aileron
- Vertical axis
- Lateral axis
RIGGING CHECKS – STRUCTURAL ALIGNMENT:

- The Dihedral and Incidence angles – of most conventional modern aircraft cannot be adjusted.
- Some manufacturers – permit adjusting the wing angle of incidence to correct for a wing-heavy condition.

- The Dihedral & Incidence Angles should be checked:
  - After Hard landings or
  - After experiencing Abnormal Flight Loads
to ensure that the components are not distorted and that the angles are within the specified limits.
METHODS For CHECKING STRUCTURAL ALIGNMENT and RIGGING ANGLES:

1. **Special rigging boards** which incorporate, or on which can be placed, a special instrument (**Spirit Level** or **Clinometer**) for determining the angle are used on some aircraft.

2. On a number of aircraft the alignment is checked using – a **Transit** and a **Plumb Bobs**, or

3. Using a **Theodolite** and **Sighting Rods**.

- The particular equipment to use is usually specified in the manufacturer’s Manuals.
CHECKS to be Carried Out Once the Aircraft is in Rigging Position:

(1) Wing (Main-plane) Dihedral and Incidence angles.
(2) Horizontal stabilizer (Tail-plane) – Dihedral and Incidence angles. If the tailplane is adjustable, it is set to neutral first.
(3) Vertical Stabilizer (Fin) - Verticality.
(4) Fuselage – Bowing in the vertical plane (Hogging and Sagging).
(5) A Symmetry check.
(6) Engine Alignment.
(1) Checking Incidence Angle

- **Incidence Angle** (or **Angle of Incidence**) or **the Angle of Wing Setting** - is:

  The acute angle between the chord line of the wing and a line parallel to the longitudinal axis of the aircraft.

- The angle of the chord line of the Wing / Main-plane (or the Tail-plane /Hz. Stab) makes with the longitudinal datum line.

- **The angle of incidence** in most cases is a fixed, built-in angle.
Incidence Angle (or Angle of Incidence) (cont’d):

- When the **Leading Edge (L.E)** of the wing is **Higher than** the Trailing Edge (T.E), the angle of incidence is said to be **Positive**.
- When the L.E is **Lower than** the T.E wing, the angle of incidence is **Negative**.
(1) Checking Incidence Angle

GBR. (a) Airplane

GBR. (b) Wing

Longitudinal Datum Line

Angle of Incidence

Chord line of wing

Longitudinal axis

Leading Edge

Chord Line

Trailing Edge

Line Parallel To Longitudinal Axis
(1) Checking Incidence Angle

Figure 2-4. Angle of incidence.
(1) Checking Incidence Angle

• Incidence is usually checked in at least 2 (two) specified positions on the surface of the wing to ensure that the wing is free from twist.

• The angle of Incidence – is checked by: positioning the Incidence Board (Fig.2-69) on the datum points of the Main/Tail plane (Wing/Horiz. Stab), [found in the manual and often marked on the aircraft, but are usually on the strong points, such as the Front and Rear Spars].
(1) Checking Incidence Angle

• **An inclinometer** – is placed on the board and the bubble position is checked that it is at zero degrees or adjust the inclinometer until the bubble reads zero, and note the amount of angle the plane is out of true.

• CHECK this with tolerances given in the AMM and record.
(1) Checking Incidence

**Variety of INCIDENCE BOARDS TO CHECK THE INCIDENCE ANGLE:**

a) **PEG BOARD** with location PEGS on spars & STOP on Leading Edge. The boards are kept clear of the wing contour by short extension attached to the board. *Figures 2-69 & 32 are typical incidence boards.*

b) **PROFILE BOARD** with PEGS resting on spars. Adjustable Level or An inclinometer is placed on the board and the bubble position is checked that it is at zero degrees or adjust the inclinometer until the bubble reads zero and note the amount of angle the the plane is out of true. *Fig. 32.b.*

Check this with the tolerances given in the AMM and record *(catat).* The purpose in either case is to ensure that the board is fitted in exactly in the position intended.
(1) Checking Incidents Angle

Figure 2-69. A typical incidence board.
(1) Checking Incidents Angle

Fig. 32 – shows the use of a **Profile Board** and a **Peg Board**. These are supplied with the aircraft.
(2) Checking Dihedral Angle

- **Dihedral Angle** – is the upward and outward inclination of the Wing (main-plane) or Horizontal Stabilizer (tail-plane) to lateral datum line.

- **Dihedral Angle is (+ Plus):** when the Wing / Hz stab (tailplane) inclined upwards;

- **Dihedral Angle is (– Minus) or Anhedral:** when the wing / horiz. stab(tailplane) inclined downwards;

- **Dihedral Angle is (0 Zero):** when the wing / horiz. stab(tailplane) straight.
(2) Schematic of Dihedral and Anhedral angle of an aircraft wing.
(2) Checking Dihedral Angle

- **DIHEDRAL ANGLE** – may be checked using:
  
a) The Spirit Level Method; Or
  
b) The Theodolite Method.

![Dihedral Angle Diagram](image-url)
(2) Checking Dihedral Angle

(2) CHECKING DIHEDRAL ANGLE:

Dihedral Angle – may be checked using:

– The Special boards provided by Aircraft Manufacturer with Spirit Level incorporated, or

– If no such board is available, a Straight Edge and a Clinometer (adjustable level) can be used.

– The Spirit Level Method or the Theodolite method.

The methods for checking dihedral are shown in Figure 2-68.

• It is important that the dihedral be checked at the positions specified by manufacturer.
(2) Checking Dihedral Angle

Figure 2-68. CHECKING DIHEDRAL
(2) Checking Dihedral Angle

a) **SPIRIT LEVEL METHOD** – The principle of checking the Dihedral Angle is similar to that for checking the Incidence Angle.

- In other words place the correct incidence board on the correct position on the Wing (Main-plane) /Horizontal Stabilizer (Tailplane).
- Place a Clinometer /Spirit Level on it and check how far the wing /tailplane is out of true.

- **When using a Straight Edge** – an *adjustable level* or a *clinometer* is used to ascertain the angle – this is checked against the AMM.

- **When a Dihedral Board** is used – a *Spirit Level* is used which *should read Zero*, or within a specified tolerance, if angle is Correct.
(2) Checking Dihedral Angle

Fig. 34 CHECKING DIHEDRAL ANGLE
THEODOLITE METHOD — This method uses a set of Sighting Rods and a Theodolite.

- The rods are screwed into specific positions on the underside of the Main-plane (wing), usually along the main spar, and looked at through the theodolite.
- Each rod has a datum line with graduations marked up and down from the zero datum.
- When looked at through the theodolite sight-glass, the sighting rod datum aligns with a datum line in the eyepiece of the theodolite, if the wing (mainplane) is at the correct angle.
b) THEODOLITE METHOD – (cont’d-1)

- The Theodolite is set on a Tripod in front of the aircraft and aligned and zeroed with the master-rod (usually the shortest).
- It is then swung around to the next rod along the wing and aligned with it.
- If the Wing /main-plane dihedral angle is correct then its zero datum will align with Theodolite datum.
- The next rod is checked, and so on until all rods have been checked. The readings are then recorded.
(2) Checking Dihedral Angle

b) THEODOLITE METHOD – (cont’d-2)

– Checked any discrepancies with the AMM and previously recorded readings in the aircraft Log Book.

– Take rectification action if necessary. Note that actual readings are recorded in the Log Book with tolerances laid down in the AMM.

– Distortion of the Wing or an incorrect Dihedral Angle will be revealed by non-alignment of the sighting rod marks when viewed through the eye-piece of Theodolite.
(2) Checking Dihedral Angle

b) THEODOLITE METHOD – (cont’d-3)

NOTE:

A Theodolite – *is an instrument that is set up using very accurate built-in spirit levels to be horizontal.*

When the sighting head is moved around in this condition it will traverse in a horizontal plane. Thus, on a perfect wing (rare) – the datum on each sighting rod will align with the theodolite eye-piece datum.

On Electronic Theodolites – they are self-levelling and readings can be recorded and printed by the instrument.

01/12/2016
(2) Checking Dihedral Angle

Fig. 35 USING THE THEODOLITE
(2) Checking Dihedral Angle

Fig. 37 SIGHTING VARIATION

“X” is the error to be checked against the AMM

THEODOLITE

SIGHTING ROD

ACTUAL SIGHTING LINE

THEORETICAL CORRECT SIGHTING LINE

X

01/12/2016

75
(3) Checking Fin (Vert stab) Verticality

- **After** the rigging of the Horizontal Stabilizer has been checked, then..

- **The verticality of the Vertical Stabilizer relative to the lateral datum can be checked.**

- **Measurements are taken:** From a given point on either side of the top of the Vert.Stab (Fin) – **to** – a given point on the left and right Horiz. Stab. (Fig.2-70).

- The measurements should be similar within prescribed limits.
(3) Checking Fin (Vert stab) Verticality

- **With a non-swept Fin**, a Plumb Bob hung from the top hinge of the rudder should align with all the other bottom hinges.
- **With a swept Fin**, Plum Bobs are hung from each hinge and must align with a center line marked out on the hangar floor – which is the center line of the aircraft (see Fig. 38).
- In other cases a symmetry check may be carried out.
(3) Checking Fin (Vert stab) Verticality

Fig. 38 FIN VERTICALITY
(3) Checking Fin (Vert stab) Verticality

- Measurements are taken – From a given point on either side of the top of the Vertical Stabilizer (Fin) – to – a given point on the left and right Horiz. Stab. (Fig. 2-70).
- The measurements should be similar within prescribed limits.

**RUDDER- HINGES ALIGNMENT CHECK :**
- Remove the Rudder, and pass a Plum Bob Line through the rudder hinge attachment holes.
Note that, some A/C have the L.E of the Vertical Fin (V. Stab.) offset to the longitudinal center line to counter act engine torque. (see Fig. 38)
(3) Checking Fin (Vert stab) Verticality

Fig. 38 FIN VERTICALITY

String or tape measure lateral datum

Figure 2-70. Checking fin verticality.
(4) **Check FUSELAGE – Bowing in the vertical plane (Hogging and Sagging).**

- **A Heavy Landing** – is likely to cause hogging.

- **Hogging**: the fuselage bent so that it is high in the middle and low at the nose and tail.

- **Sagging**: is the opposite of hogging.
(4) Checking Fuselage for Twist & Bending

Theodolite use:

- Checking for Hogging / Sagging of the Fuselage [see Fig. 36(a)];
- Checking for Wing Twist and Negative Dihedral (Anhedral) [see Fig. 36(b)].
(4) Checking Fuselage for Twist & Bending

Diagram of ship hull (1) Sagging and (2) Hogging under loads. Bending is exaggerated for demonstration purposes.
(1) Sagging and (2) Hogging
(4) Checking Fuselage for Twist & Bending

Fig. 35 USING THE THEODOLITE

Fig. 37 SIGHTING VARIATION
Fig. 36: THEODOLITE USE – BAe 146
Fig. 36 (a) : THEODOLITE USE (Exploded View)/ (diperbesar)
Fig. 36 (b) : THEODOLITE USE
(Exploded View)

Examples of Wing Sighting Rod Readings
Rods are graduated in 5 minute divisions

Checking for hogging/sagging of the fuselage
Checking for wing twist and negative dihedral (anhedral)

Fig. 36 THEODOLITE USE – BAe 146
Wing Twist Check

Figure 9-48.—Alignment data—wing twist check.
Airframe Symmetry:

- Methods of Alignment and
- Symmetry Checks
(5) Alignment or Symmetry Check

• The Alignment or Symmetry check - is made After the Aircraft has been Leveled.
• This check is made by - Measuring the distance between certain Points on the aircraft.
• These Points are selected because they are relatively static and because their location will best reflect any misalignment.
• Most manufacturers recommend that the measurements be taken directly from one specified point to another.
(5) Aircraft Symmetry

Plane of symmetry

Line perpendicular to plane of symmetry

Dihedral angle
Control Points for Symmetry and Alignment Checks
Figures 1 & Fig. 39 illustrate the principle of a Typical Symmetry Check.

The precise Figures, Tolerances, and Checkpoints, for a particular a/c – are given in the applicable Service or AMM (Airplane Maintenance Manual).

In some cases – the measurements may be recorded in the aircraft Log Book.
(5) A Typical Method of Checking Aircraft Symmetry

### Dimensional Tolerances

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Equation</th>
<th>Units</th>
</tr>
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<tbody>
<tr>
<td>MR</td>
<td>ML ± 1.0 inch (25.4 mm)</td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>NL ± 1.0 inch (25.4 mm)</td>
<td></td>
</tr>
<tr>
<td>PR</td>
<td>PL ± 1.0 inch (25.4 mm)</td>
<td></td>
</tr>
<tr>
<td>RR</td>
<td>RL ± 0.5 inch (12.7 mm)</td>
<td></td>
</tr>
<tr>
<td>SR</td>
<td>SL ± 0.25 inch (6.35 mm)</td>
<td></td>
</tr>
<tr>
<td>TR</td>
<td>TL ± 0.25 inch (6.35 mm)</td>
<td></td>
</tr>
</tbody>
</table>

Each measurement point (A, B, C, D, E, F, & G) is given a precise airframe location in the manual. Each pair of measurements (e.g., MR & ML) should be equal plus or minus the stated tolerance.
For SMALL AIRCRAFT – the measurements are taken using a steel tape measure, and To allow for tape sag a spring balance is used tensioned to say 5 lbs. In this way, there will be some sag in the tape, but it will be the same for all measurements. Remember, it is the differences in the measurements that we are looking for.
(5) Symmetry Check

• For LARGER AIRCRAFT – a plumb bob is used to transfer each measurement point to the floor of the hangar, marking the position with chalk.

• This is done by suspending a plumb bob from the check-points, and marking the floor immediately under the point of each plumb bob.

• The points on the floor are then measured using the steel tape.

• This method may be easier than trying to measure with a long steel tape on a ladder several feet up in the air.
• **The QUESTION - is**: Why are tolerances only given and not actual dimensions?

• **The ANSWER - is**: 

  • The coefficient of linear expansion of Aluminium alloy is quite high (in fact its coefficient of linear expansion is $23 \times 10^{-6}$, where as steel is nearly half this value), so as the Temperature of airframe changes so will its size.

  • Quoted dimensions therefore would be irrelevant.
Relationship Between the Manual and the Aircraft Log Book:

- On the 1st Rigging check (at manufacturers) – the reading obtained are Recorded in the Aircraft Log Book. Subsequently, any readings taken should be compared with these.

- Tolerances (e.g. Variations) are laid down in the AMM.

- The manual is common to all aircraft of a particular type, but each aircraft will have its own log book readings.
Figure 2-71: Checking Engine Alignment
(6) Engine Mounting

- Engines attached to the Wings - may be mounted with the Thrust line parallel to the horizontal longitudinal plane of symmetry, but not always parallel to the vertical longitudinal plane (they may be inclined slightly outwards).

- The check to ensure that the position of the engine, including any degree of offset, – is correct depends on the Manual, but usually entails measurements from the center line of the engine to the longitudinal center line of the Fuselage. (see Figure 2-71)

- Any longitudinal horizontal plane offset/balanced may be measured using an Inclinometer.
(6) Engine Mounting

Figure 2-71: Checking Engine Alignment

Figure 2-71. A typical method of checking aircraft symmetry.
Helicopter Rigging
Helicopter Rigging

![Diagram of helicopter controls and their functions]

**Figure 2-72.** Controls of the helicopter and the principal function of each.
Selected Definitions, Terms, and Abbreviations,
• **Angle of attack (AOA).** The acute angle formed *between* the chord line of an airfoil and the direction of the relative wind (air striking the airfoil).
• **Angle of incidence.** The angle formed by the chord line of the wing and a line parallel to the longitudinal axis of the airplane.

• **Dihedral.** The positive acute angle between the lateral axis of an airplane and a line through the center of a wing or horizontal stabilizer. Dihedral contributes to the lateral stability of an airplane.
Definisi:

Dihedral

Sweepback
Assembly & Rigging - Definition

• **Assembly** – involves putting together the component sections of aircraft, such as wing sections, empennage units, nacelles, and landing gear.

• **Rigging** - is the final adjustment and alignment of the various component sections to provide the proper aerodynamic reaction.
Singkatan / Abbreviations

- **AMM**: Aircraft Mainenance Manual
- **FMS**: Flight Management System.
- **TCDS**: Type Certificate Data Sheet.
Rujukan / References:

1. FAA- AC 65-15A, Ch.2, Rigging hal. 70 ~ dst.;
   (Structural Alignment p. 72 f.)

2. JSAT A/F: Chapter 1, Ch.1, hal.1-37 dst:
   “Airplane Assy & Rigging”,

3. Aviation Structural Mechanic (H&S) 3&2

4. CN235 Structural Repair Manual (SRM),
   Chapter 51-50-00, Mar. 15/01

5. EASA – Airbus Structure.