Lesson 7 part 2

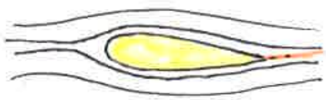
FARS / 14CFR 23

AC 23-8 Flight test guide for 14CFR 23

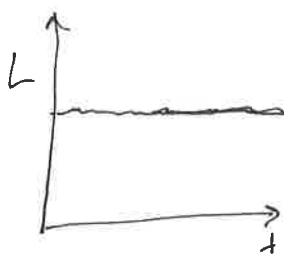
Buffet

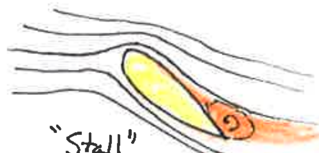
In 14 CFR 23, buffet near M_{mo} is specifically mentioned. Let's look at the physics of buffet for a minute.

Buffet is vibration caused by flow separation

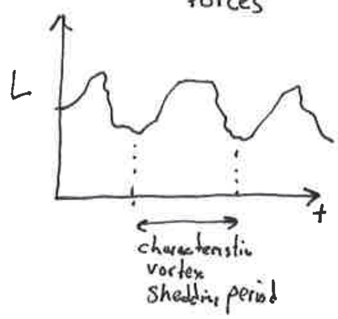


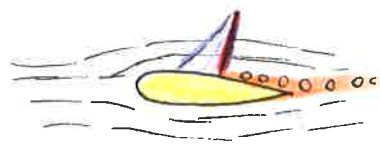
"attached flow"
little to no separation



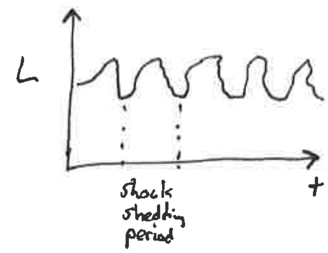


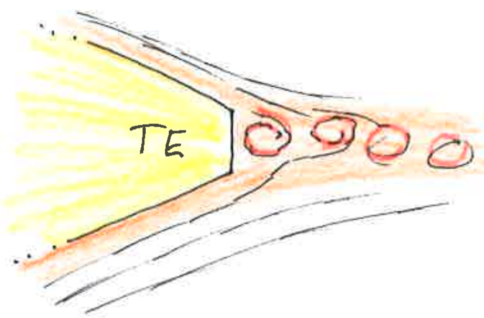
"Stall"
Low speed separation
unsteady lift/drag forces





High Mach #
Shock induced separation
Unsteady





"Attached" flow still has a small separated TE region. We primarily <u>hear</u> this separation as "wind noise".

The separation near and past stall is relatively low frequency. We primarily feel this through the flight control system and wing drop / roll off. This is particularly true if the wake interacts w/ the horiz/elevator.

This separation is characterized by higher frequency vibration throughout the vehicle (although separation on control surfaces may occur).

The frequency and amplitude can be <u>damaging</u> to the pilot and/or aircraft

Buffet onset depends on

M, α, configuration

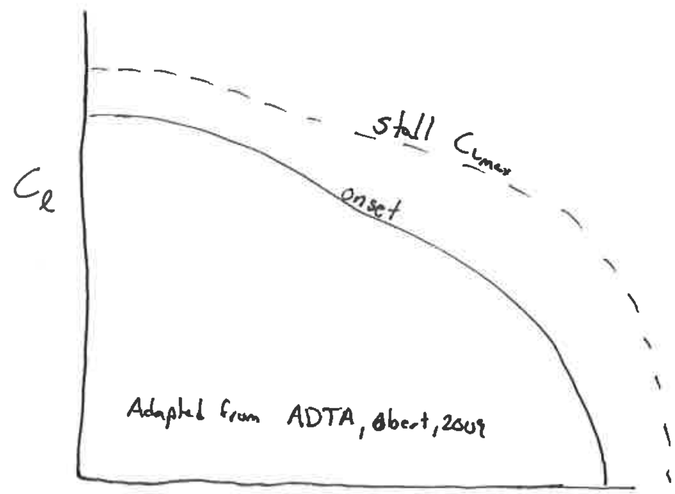
Ex: Spoiler

After some time in an airplane, you can tell the configuration and state by the sound.

My 172 that I trained on would "sing" to me at approach speed!!

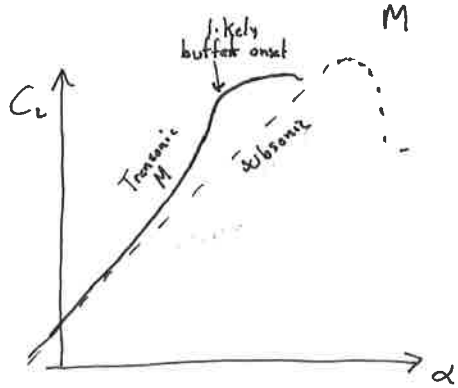
A buffer between normal operating conditions and the onset of buffet is necessary

- Certification requirements
- Passenger comfort and acceptance
- Fatigue + Failure
- Pilot (annoyance to vision problems to incapacitation)
- Upset at M_{mo}
- Manuevers (α)



Determining Buffet onset

- Noise, Vibration
- C_L vs α
- Pitching Moment
  Downwash Change
- C_p distribution on airfoil
  - divergence of C_p at TE is a classic method
- See Roskam for a list of 15 methods



FAR 23 Design and Construction

"Workmanship must be of a high standard."

Castings must be inspected depending on "casting factor" to account for voids and material issues in casted objects. CF = 1.25 requires non-destructive testing (radiographic, magnetic).

Flutter: Aerostructural instabilities: We will discuss later.
Must be free from flutter within v-n envelope (up to V_D/M_D)
Natural frequencies must be tested

tiny.cc/AEM617Flutter 0:42 → 1:05

§23.627 Fatigue strength.

The structure must be designed, as far as practicable, to avoid points of stress concentration where variable stresses above the fatigue limit are likely to occur in normal service.

§23.629 Flutter.

(a) It must be shown by the methods of paragraph (b) and either paragraph (c) or (d) of this section, that the airplane is free from flutter, control reversal, and divergence for any condition of operation within the limit V-n envelope and at all speeds up to the speed specified for the selected method. In addition—

(1) Adequate tolerances must be established for quantities which affect flutter, including speed, damping, mass balance, and control system stiffness; and

(2) The natural frequencies of main structural components must be determined by vibration tests or other approved methods.

(b) Flight flutter tests must be made to show that the airplane is free from flutter, control reversal and divergence and to show that—

(1) Proper and adequate attempts to induce flutter have been made within the speed range up to V_D/M_D, or V_{DF}/M_{DF} for jets;

(2) The vibratory response of the structure during the test indicates freedom from flutter;

(3) A proper margin of damping exists at V_D/M_D, or V_{DF}/M_{DF} for jets; and

(4) As V_D/M_D (or V_{DF}/M_{DF} for jets) is approached, there is no large or rapid reduction in damping.

(c) Any rational analysis used to predict freedom from flutter, control reversal and divergence must cover all speeds up to 1.2 V_D/1.2 M_D, limited to Mach 1.0 for subsonic airplanes.

(d) Compliance with the rigidity and mass balance criteria (pages 4–12), in Airframe and Equipment Engineering Report No. 45 (as corrected) "Simplified Flutter Prevention Criteria" (published by the Federal Aviation Administration) may be accomplished to show that the airplane is free from flutter, control reversal, or divergence if—

(1) V_D/M_D for the airplane is less than 260 knots (EAS) and less than Mach 0.5,

(2) The wing and aileron flutter prevention criteria, as represented by the wing torsional stiffness and aileron balance criteria, are limited in use to airplanes without large mass concentrations (such as engines, floats, or fuel tanks in outer wing panels) along the wing span, and

(3) The airplane—

(i) Does not have a T-tail or other unconventional tail configurations;

(ii) Does not have unusual mass distributions or other unconventional design features that affect the applicability of the criteria, and

(iii) Has fixed-fin and fixed-stabilizer surfaces.

(e) For turbopropeller-powered airplanes, the dynamic evaluation must include—

(1) Whirl mode degree of freedom which takes into account the stability of the plane of rotation of the propeller and significant elastic, inertial, and aerodynamic forces, and

(2) Propeller, engine, engine mount, and airplane structure stiffness and damping variations appropriate to the particular configuration.

(f) Freedom from flutter, control reversal, and divergence up to V_D/M_D must be shown as follows:

(1) For airplanes that meet the criteria of paragraphs (d)(1) through (d)(3) of this section, after the failure, malfunction, or disconnection of any single element in any tab control system.

(2) For airplanes other than those described in paragraph (f)(1) of this section, after the failure, malfunction, or disconnection of any single element in the primary flight control system, any tab control system, or any flutter damper.

(g) For airplanes showing compliance with the fail-safe criteria of §§23.571 and 23.572, the airplane must be shown by analysis to be free from flutter up to V_D/M_D after fatigue failure, or obvious partial failure, of a principal structural element.

(h) For airplanes showing compliance with the damage tolerance criteria of §23.573, the airplane must be shown by analysis to be free from flutter up to V_D/M_D with the extent of damage for which residual strength is demonstrated.

(i) For modifications to the type design that could affect the flutter characteristics, compliance with paragraph (a) of this section must be shown, except that analysis based on previously approved data may be used alone to show freedom from flutter, control reversal and divergence, for all speeds up to the speed specified for the selected method.

[Amdt. 23–23, 43 FR 50592, Oct. 30, 1978, as amended by Amdt. 23–31, 49 FR 46867, Nov. 28, 1984; Amdt. 23–45, 58 FR 42164, Aug. 6, 1993; 58 FR 51970, Oct. 5, 1993; Amdt. 23–48, 61 FR 5148, Feb. 9, 1996; Amdt. 23–62, 76 FR 75756, Dec. 2, 2011]

WINGS

§ 23.641 Proof of strength.

The strength of stressed-skin wings must be proven by load tests or by combined structural analysis and load tests.

CONTROL SURFACES

§ 23.651 Proof of strength.

(a) Limit load tests of control surfaces are required. These tests must include the horn or fitting to which the control system is attached.

(b) In structural analyses, rigging loads due to wire bracing must be accounted for in a rational or conservative manner.

§ 23.655 Installation.

(a) Movable surfaces must be installed so that there is no interference between any surfaces, their bracing, or adjacent fixed structure, when one surface is held in its most critical clearance positions and the others are operated through their full movement.

(b) If an adjustable stabilizer is used, it must have stops that will limit its range of travel to that allowing safe flight and landing.

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964, as amended by Amdt. 23–45, 58 FR 42164, Aug. 6, 1993]

§ 23.657 Hinges.

(a) Control surface hinges, except ball and roller bearing hinges, must have a factor of safety of not less than 6.67 with respect to the ultimate bearing strength of the softest material used as a bearing.

(b) For ball or roller bearing hinges, the approved rating of the bearing may not be exceeded.

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964, as amended by Amdt. 23–48, 61 FR 5148, Feb. 9, 1996]

§ 23.659 Mass balance.

The supporting structure and the attachment of concentrated mass balance weights used on control surfaces must be designed for—

(a) 24 *g* normal to the plane of the control surface;

(b) 12 *g* fore and aft; and

(c) 12 *g* parallel to the hinge line.

CONTROL SYSTEMS

§ 23.671 General.

(a) Each control must operate easily, smoothly, and positively enough to allow proper performance of its functions.

(b) Controls must be arranged and identified to provide for convenience in operation and to prevent the possibility of confusion and subsequent inadvertent operation.

§ 23.672 Stability augmentation and automatic and power-operated systems.

If the functioning of stability augmentation or other automatic or power-operated systems is necessary to show compliance with the flight characteristics requirements of this part, such systems must comply with § 23.671 and the following:

(a) A warning, which is clearly distinguishable to the pilot under expected flight conditions without requiring the pilot's attention, must be provided for any failure in the stability augmentation system or in any other automatic or power-operated system that could result in an unsafe condition if the pilot was not aware of the failure. Warning systems must not activate the control system.

(b) The design of the stability augmentation system or of any other automatic or power-operated system must permit initial counteraction of failures without requiring exceptional pilot

Control System

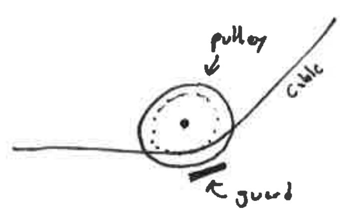
- Must operate "easily, smoothly and positively".
- Controls must be arranged and identified

- Primary flight Controls
  - pitch, roll, yaw
  - Must have stops

- Trim
  - Must to prevent inadvertent, improper operation
  - Must indicate trim position
  - Single engine - longnitudinal
  - Multi engine - longitudinal <u>and</u> directional

- Control Lock
  - <u>Must</u> show when engaged
  - Disengaged when pilot operates controls
  - Warning if engaged at takeoff
  - Preclude engaging in flight

- Cables
  - 1/8 in or larger
  - pulleys must have guards



Landing Gear

- For commuter aircraft with >10 px, if the gear fails, a fuel fire hazard is "not likely".
- Drop test at

$$h^{[inches]} = 3.6 \left(\frac{W}{S}\right)^{1/2}$$ between 9.2 and 18.7 inches

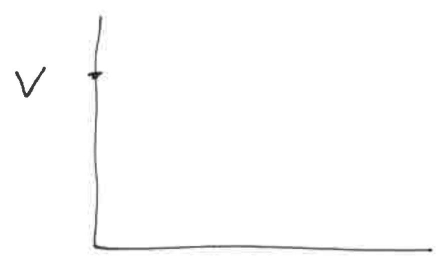
- Retract locks down (other than hydraulic pressure) "Down and Locked"
- Géár must have a manual extension method
- Position indicator
- Warning if {gear is retracted / flaps are extended} with below approach power

Brakes must be provided

- Kinetic energy capacity

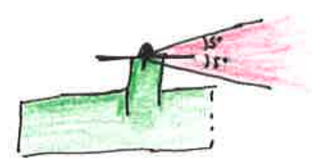
$$KE^{[ft \cdot lb]} = 0.0443 \cdot W^{[lb]} \cdot V_s^{2\,[kts]} \frac{1}{N}$$

← # wheels w/ brakes



Cockpit

No part of the pilot or controls lies in the ±5° arc from a propeller



Pilots view

- Undistorted view to taxi, T/O, App, land, and perform manuevers
- Free from glare + reflections.
- Protected from elements such that moderate rain does not impair vision
- Must remove or prevent fog + frost
- Must transmit 70% light through forward + side transparencies
- Must stop a 2 lb bird at max flap speed (Commuter category)

Controls

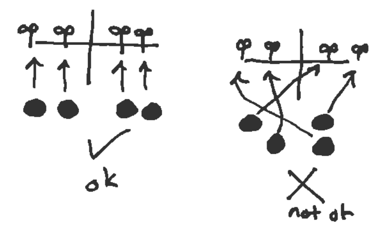
- Must be located and identified. Reachable from pilot's seat
- Powerplant

  Single + Tandem : Left
  Multiengine : Center, top on pedestal
  others : Center or 2 sets

- Order of Controls

  [Power], [propeller], [mixture]
  [LG] [Carb heat] [Supercharger] [Flaps]

Identical controls must prevent confusion



- Aero controls
  - Flaps centrally located or right of power
  - LG left of power

- Fuel

  Must be arranged such the pilot can see and operate fuel selector

  Ex: John Denver

  OFF is Red

confusion as to the engines they control.

(1) Conventional multiengine powerplant controls must be located so that the left control(s) operates the left engines(s) and the right control(s) operates the right engine(s).

(2) On twin-engine airplanes with front and rear engine locations (tandem), the left powerplant controls must operate the front engine and the right powerplant controls must operate the rear engine.

(f) Wing flap and auxiliary lift device controls must be located—

(1) Centrally, or to the right of the pedestal or powerplant throttle control centerline; and

(2) Far enough away from the landing gear control to avoid confusion.

(g) The landing gear control must be located to the left of the throttle centerline or pedestal centerline.

(h) Each fuel feed selector control must comply with §23.995 and be located and arranged so that the pilot can see and reach it without moving any seat or primary flight control when his seat is at any position in which it can be placed.

(1) For a mechanical fuel selector:

(i) The indication of the selected fuel valve position must be by means of a pointer and must provide positive identification and feel (detent, etc.) of the selected position.

(ii) The position indicator pointer must be located at the part of the handle that is the maximum dimension of the handle measured from the center of rotation.

(2) For electrical or electronic fuel selector:

(i) Digital controls or electrical switches must be properly labelled.

(ii) Means must be provided to indicate to the flight crew the tank or function selected. Selector switch position is not acceptable as a means of indication. The "off" or "closed" position must be indicated in red.

(3) If the fuel valve selector handle or electrical or digital selection is also a fuel shut-off selector, the off position marking must be colored red. If a separate emergency shut-off means is provided, it also must be colored red.

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964, as amended by Amdt. 23–7, 34 FR 13092, Aug. 13, 1969; Amdt. 23–33, 51 FR 26656, July 24, 1986: Amdt. 23–51, 61 FR 5136, Feb. 9, 1996; Amdt. 23–62, 76 FR 75757, Dec. 2, 2011]

§23.779 Motion and effect of cockpit controls.

Cockpit controls must be designed so that they operate in accordance with the following movement and actuation:

(a) Aerodynamic controls:

	Motion and effect
(1) *Primary controls:*	
Aileron	Right (clockwise) for right wing down.
Elevator	Rearward for nose up.
Rudder	Right pedal forward for nose right.
(2) *Secondary controls:*	
Flaps (or auxiliary lift devices).	Forward or up for flaps up or auxiliary device stowed; rearward or down for flaps down or auxiliary device deployed.
Trim tabs (or equivalent).	Switch motion or mechanical rotation of control to produce similar rotation of the airplane about an axis parallel to the axis control. Axis of roll trim control may be displaced to accommodate comfortable actuation by the pilot. For single-engine airplanes, direction of pilot's hand movement must be in the same sense as airplane response for rudder trim if only a portion of a rotational element is accessible.

(b) Powerplant and auxiliary controls:

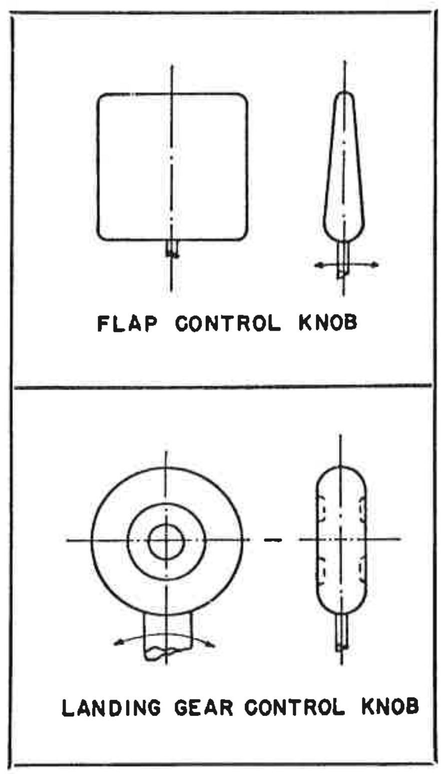
	Motion and effect
(1) *Powerplant controls:*	
Power (thrust) lever.	Forward to increase forward thrust and rearward to increase rearward thrust.
Propellers	Forward to increase rpm.
Mixture	Forward or upward for rich.

	Motion and effect
Fuel	Forward for open.
Carburetor, air heat or alternate air.	Forward or upward for cold.
Supercharger.	Forward or upward for low blower.
Turbosuperchargers.	Forward, upward, or clockwise to increase pressure.
Rotary controls.	Clockwise from off to full on.
(2) *Auxiliary controls:*	
Fuel tank selector.	Right for right tanks, left for left tanks.
Landing gear.	Down to extend.
Speed brakes.	Aft to extend.

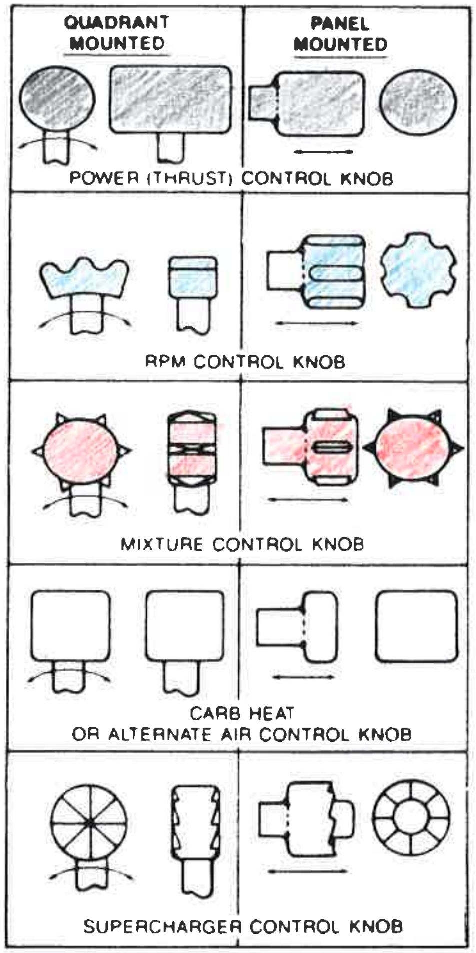
[Amdt. 23–33, 51 FR 26656, July 24, 1986, as amended by Amdt. 23–51, 61 FR 5136, Feb. 9, 1996]

§ 23.781 Cockpit control knob shape.

(a) Flap and landing gear control knobs must conform to the general shapes (but not necessarily the exact sizes or specific proportions) in the following figure:



Color not a regulation:



black

blue

red

(b) Powerplant control knobs must conform to the general shapes (but not necessarily the exact sizes or specific proportions) in the following figure:

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964; 30 FR 258, Jan. 9, 1965, as amended by Amdt. 23–33, 51 FR 26657, July 24, 1986]

§ 23.783 Doors.

(a) Each closed cabin with passenger accommodations must have at least one adequate and easily accessible external door.

(b) Passenger doors must not be located with respect to any propeller disk or any other potential hazard so as to endanger persons using the door.

(c) Each external passenger or crew door must comply with the following requirements:

(1) There must be a means to lock and safeguard the door against inadvertent opening during flight by persons, by cargo, or as a result of mechanical failure.

(2) The door must be openable from the inside and the outside when the internal locking mechanism is in the locked position.

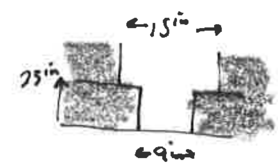
Seats:

- Must be a seat for each passenger
- Seat and restraint (seat belt) must be designed to withstand flight and ground loads w/ 215 occupants at an additional Factor of Safety of 1.33
- Single point release for restraints systems
- Seat track must have stops

History lesson on seats: Cessna quit making aircraft for several years
$480M in damages for a 1989 crash
AD in 1987, Service letter in 1983
Pilots "believed the seat slipped"
NTSB says no, "same relative position"
Jury says $$$, Cessna says "bye"
ATL89FA197

Emergency Evacuation

- Commuter Aircraft: 90 seconds, night, one side (critical), no practice
- Exits have many requirements. Crew and passenger
  ↖ including "above the water line"
- Lighting and exit markings
- Aisle width 9 in below 25 in and 15 in above
  for commuter the widths are increased



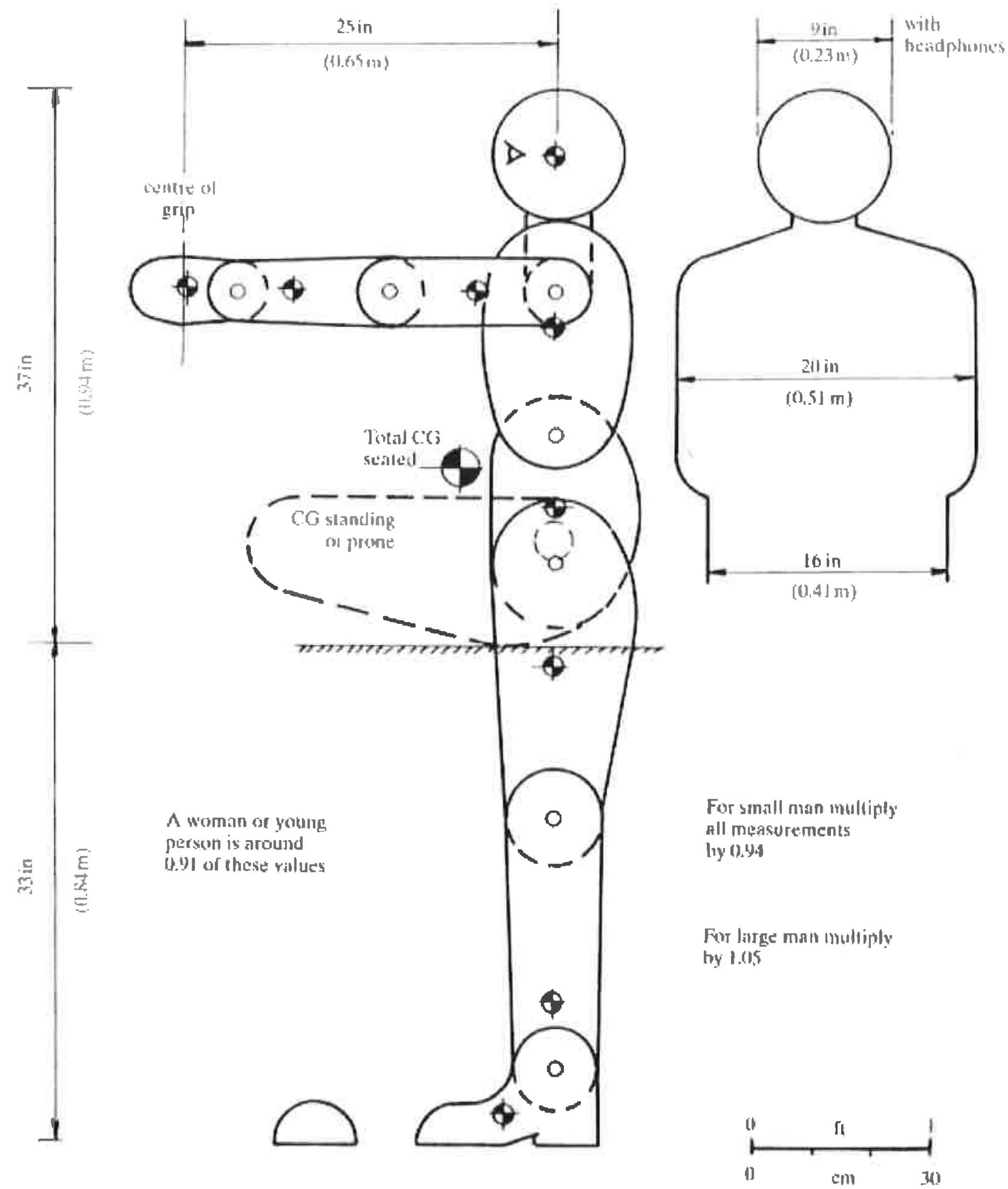


Fig. 9.2 Geometrical construction of standard man (without parachute) from straight lines and circles. Partial centres of gravity shown as small quartered circles, joints as plain circles [based upon ref. 9.1].

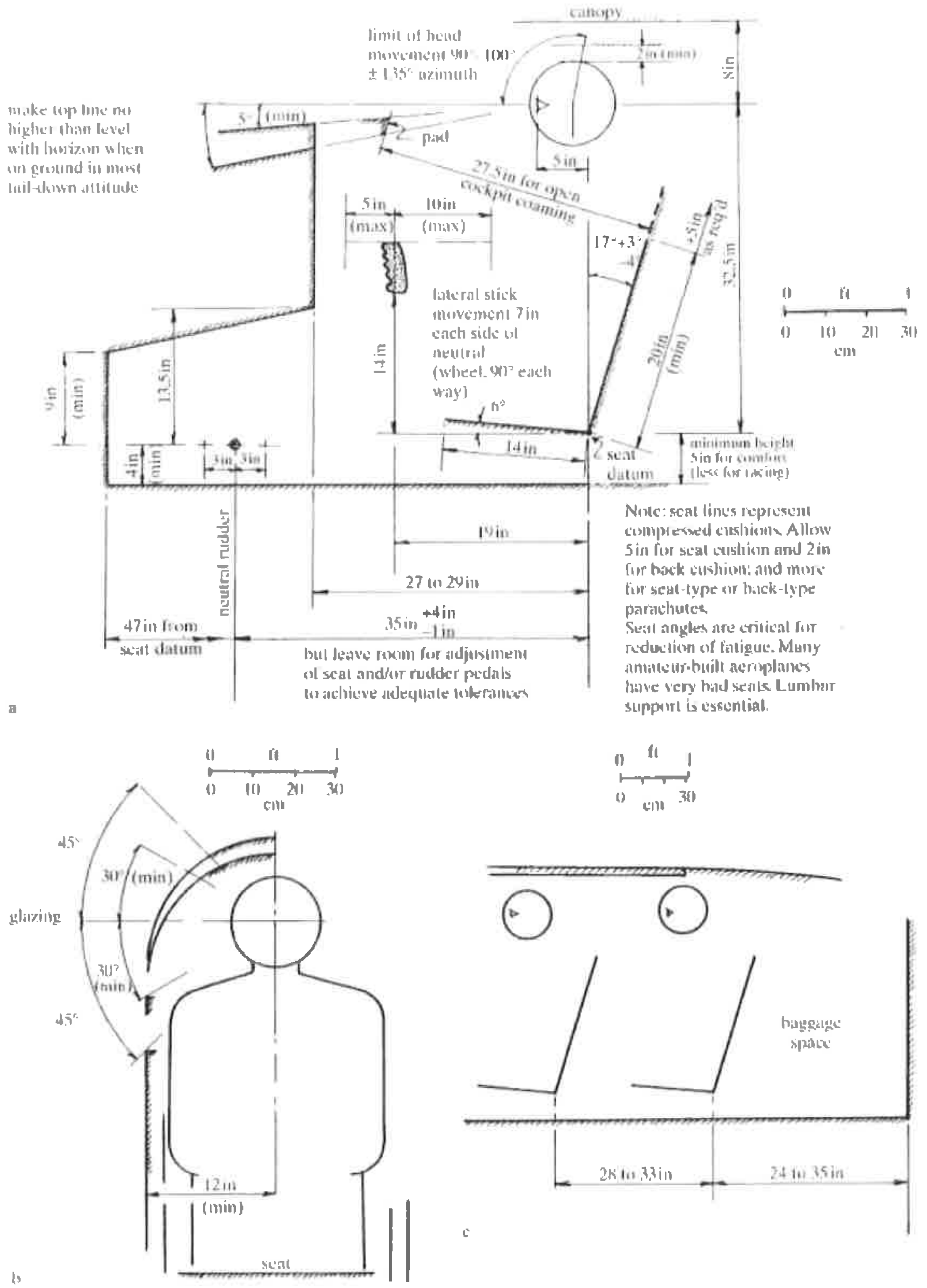


Fig. 9.3 a. Cockpit elevation. b., c. Cockpit and cabin dimensions. b. Extent of glazing and cockpit sills to enable the pilot to look out sideways in 30° and 45° banked turns it is essential to be able to look inwards during any turn, with an unobstructed view in the plane of a manoeuvre. Tandem (or 4 seat) spacing.

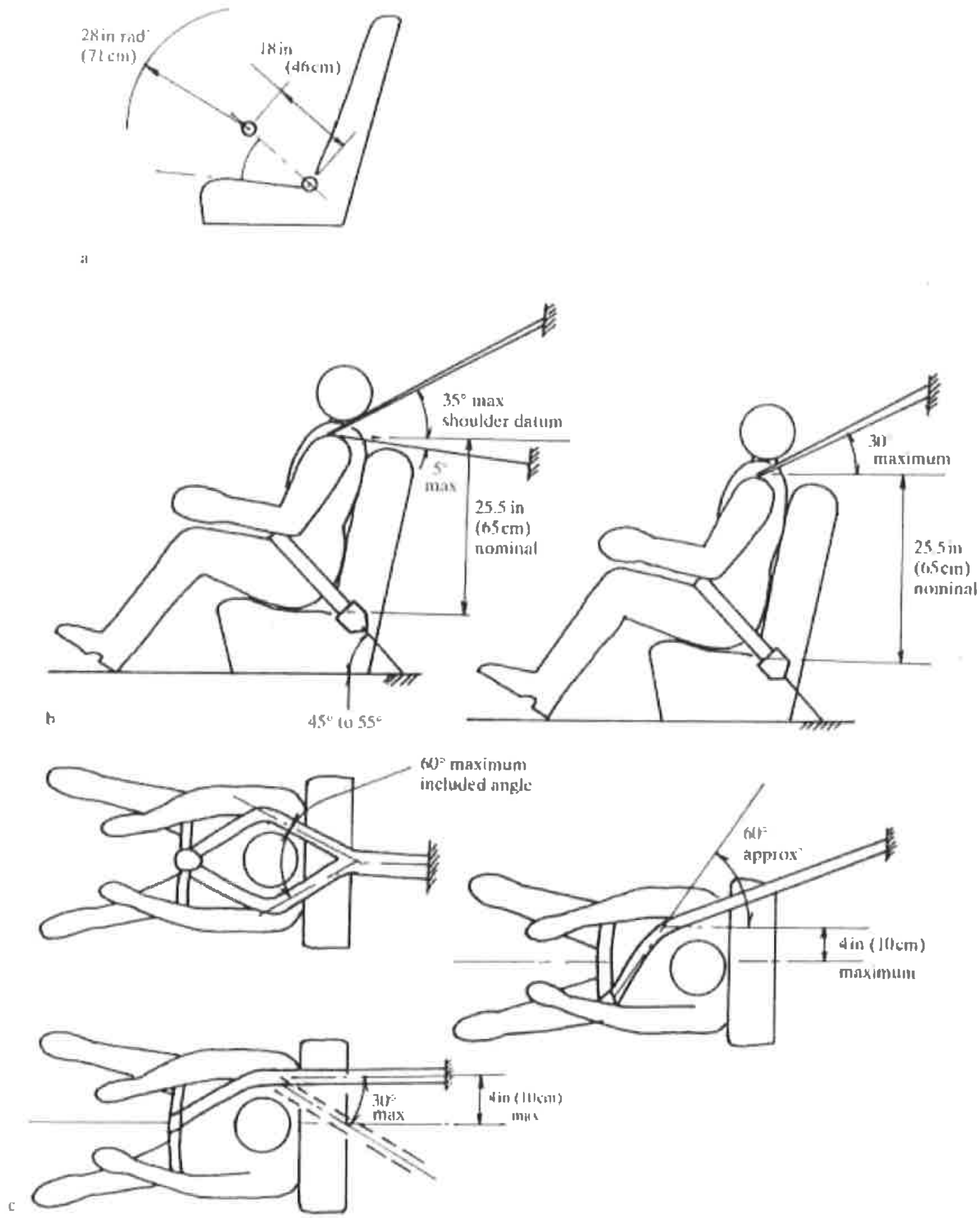


Fig. 9.4 a.–c. Safety belts and harness [ref. 9.3]. a. Radius of travel of head of occupant, allowing for stretch of seat belt and tall occupant. Within the arc all surfaces should be smooth and either flat, or of large radius. b. Shoulder harness. c. One diagonal shoulder strap. *Note*: Anchorage of shoulder harness or diagonal straps affects structural layout and arrangement of other seats. The anchor points into the structure must be able to take a load of 9.0g, plus an appropriate safety factor.