SESSION 23: AIRCRAFT SYSTEMS — VACUUM AND GYROSCOPIC SYSTEMS

1. In a conventionally equipped piston aircraft, the vacuum system typically drives which instruments?

A. The attitude indicator and the heading indicator

B. The airspeed indicator and the altimeter

C. The turn coordinator and the magnetic compass

D. The VSI and the tachometer

2. The turn coordinator in most light aircraft is powered by:

A. The vacuum system

B. Ram air pressure

C. The electrical system

D. Static pressure

3. The gyroscopic property that makes the attitude indicator hold its position relative to the horizon is:

A. Precession

B. Rigidity in space

C. Magnetic dip

D. Centrifugal reaction

4. The gyroscopic property of precession is the tendency of a gyro to:

A. Maintain a fixed orientation regardless of aircraft motion

B. Spin faster as vacuum increases

C. React to an applied force 90 degrees later in the direction of rotation

D. Align itself with magnetic north

5. An engine-driven vacuum pump failure removes the power source for:

A. The turn coordinator and magnetic compass

B. The airspeed indicator and altimeter

C. The attitude indicator and heading indicator

D. The VSI and tachometer

6. Which instruments remain available after a vacuum pump failure?

A. The attitude indicator and heading indicator

B. The turn coordinator, magnetic compass, and pitot-static instruments

C. Only the attitude indicator

D. None; all flight instruments are lost

7. The most insidious aspect of a vacuum failure is that:

A. The gyros spin down gradually, displaying plausible but increasingly erroneous information

B. All instruments fail instantly and obviously

C. The magnetic compass becomes unreliable

D. The electrical system fails simultaneously

8. The earliest and most direct indicator of a vacuum system failure is:

A. The attitude indicator tumbling violently

B. The heading indicator spinning rapidly

C. The airspeed dropping to zero

D. The vacuum gauge reading below the normal (green) range

9. A heading indicator (directional gyro) is subject to "precession error," requiring the pilot to:

A. Replace it before every IFR flight

B. Switch it to electrical power periodically

C. Realign it with the magnetic compass periodically in straight-and-level flight

D. Cage it during all turns

10. A pilot who does not recognize a vacuum failure may:

A. Follow the slowly diverging attitude indicator into an actual unusual attitude

B. Experience an immediate and obvious loss of all instruments

C. Lose the magnetic compass first

D. Have the engine quit due to the failure

11. The vacuum gauge should be included in the regular instrument scan specifically to:

A. Monitor engine oil pressure

B. Verify the electrical bus voltage

C. Check the cabin pressurization

D. Detect a vacuum failure early, before the gyros provide erroneous information

12. Many IFR aircraft carry a backup or standby system for attitude information, such as:

A. A second magnetic compass

B. An electrically driven backup attitude indicator or an electric standby instrument

C. A redundant pitot tube

D. A duplicate altimeter

13. The attitude indicator's gyro spins about which axis to sense pitch and bank?

A. A horizontal axis aligned with the longitudinal axis only

B. A vertical spin axis, keeping the gyro plane horizontal

C. The lateral axis only

D. A 45-degree canted axis

14. A "suction" or vacuum gauge reading in a typical light aircraft should be approximately:

A. 0 to 1 inch of mercury

B. 10 to 12 inches of mercury

C. 20 to 25 inches of mercury

D. 4.5 to 5.5 inches of mercury

15. Why does correlating the vacuum-driven instruments against the electric and static instruments reveal a vacuum failure?

A. The vacuum instruments always fail first and obviously

B. If the attitude/heading instruments disagree with the turn coordinator, compass, and pitot-static instruments, the vacuum instruments are suspect

C. The electric instruments fail at the same rate

D. The magnetic compass drives the attitude indicator

16. Upon recognizing a vacuum failure in IMC, the pilot should:

A. Continue trusting the attitude indicator until it fully tumbles

B. Restart the engine to restore vacuum

C. Transition to partial panel using the turn coordinator, compass, and pitot-static instruments

D. Disable the electrical system to conserve power

17. A no-gyro approach is valuable during a vacuum failure because the controller:

A. Restores vacuum power remotely

B. Provides a backup attitude indicator reading

C. Issues turn instructions the pilot executes with the turn coordinator, removing the heading-management burden

D. Takes control of the aircraft via datalink

18. Vacuum failure in IMC is appropriately handled by the pilot:

A. Declaring an emergency and requesting priority handling and assistance

B. Continuing the flight without notifying ATC

C. Squawking 1200 to indicate VFR

D. Climbing above the clouds regardless of icing or terrain

19. The turn coordinator displays:

A. Rate of turn and quality of coordination (the ball)

B. Direct pitch and bank like the attitude indicator

C. The aircraft's magnetic heading

D. The vertical speed of the aircraft

20. A standby electric attitude indicator with its own battery is valuable because it:

A. Replaces the need for a vacuum system entirely in all aircraft

B. Provides attitude information independent of the vacuum system and main electrical bus

C. Functions only on the ground

D. Powers the heading indicator directly

21. During a vacuum failure, the heading indicator will:

A. Remain perfectly accurate indefinitely

B. Instantly freeze at the current heading

C. Switch automatically to electrical power

D. Precess at an accelerating rate, diverging from the magnetic compass

22. A pilot planning a partial panel approach after a vacuum failure should ideally choose:

A. A GPS or ILS approach, which provide a course reference reducing heading-management workload

B. A VOR approach requiring timed turns and station passage

C. A circling approach in marginal conditions

D. The approach with the lowest minimums regardless of type

23. Gyroscopic rigidity in space allows the attitude indicator to:

A. Align with the Earth's magnetic field

B. Spin faster during turns

C. Indicate distance to the next waypoint

D. Maintain a stable reference plane against which pitch and bank are displayed

24. A pilot notices the attitude indicator slowly showing a bank that the turn coordinator and compass do not confirm. This indicates:

A. The turn coordinator has failed

B. The magnetic compass is precessing

C. A vacuum failure causing the attitude indicator to drift

D. Normal instrument behavior in a coordinated turn

25. The fundamental reason vacuum failure is a heavily tested IFR emergency is that:

A. It is extremely rare and largely theoretical

B. It affects only the magnetic compass

C. It is realistic in the vacuum-gyro fleet, its effects are insidious, and undetected failure has caused loss of control

D. It is always accompanied by an obvious engine failure

ANSWER KEY & EXPLANATIONS – SESSION 23

1. A. AI and HI — In a conventional piston aircraft, the vacuum system drives the attitude indicator and heading indicator.

2. C. Electrical — The turn coordinator in most light aircraft is electrically powered.

3. B. Rigidity in space — Rigidity in space makes the attitude indicator hold its orientation relative to the horizon.

4. C. React 90° later — Precession is the tendency of a gyro to react to an applied force 90 degrees later in the direction of rotation.

5. C. AI and HI lost — A vacuum pump failure removes the power source for the attitude indicator and heading indicator.

6. B. TC/compass/pitot-static — After a vacuum failure, the turn coordinator, magnetic compass, and pitot-static instruments remain available.

7. A. Gradual spin-down — The insidious aspect is that the gyros spin down gradually, displaying plausible but increasingly erroneous information.

8. D. Vacuum gauge low — The earliest direct indicator of vacuum failure is the vacuum gauge reading below the normal (green) range.

9. C. Realign with compass — The heading indicator precesses, requiring periodic realignment with the magnetic compass in straight-and-level flight.

10. A. Follow into unusual attitude — An unrecognized vacuum failure can lead the pilot to follow the slowly diverging attitude indicator into an actual unusual attitude.

11. D. Detect failure early — The vacuum gauge is scanned to detect a vacuum failure early, before the gyros provide erroneous information.

12. B. Electric backup AI — Many IFR aircraft carry an electrically driven backup attitude indicator or electric standby instrument.

13. B. Vertical spin axis — The attitude indicator's gyro spins about a vertical axis, keeping the gyro plane horizontal to sense pitch and bank.

14. D. 4.5–5.5 in Hg — A typical light-aircraft vacuum gauge reads approximately 4.5 to 5.5 inches of mercury.

15. B. Disagreement reveals failure — Correlating reveals vacuum failure because if the attitude/heading instruments disagree with the turn coordinator, compass, and pitot-static instruments, the vacuum instruments are suspect.

16. C. Transition to partial panel — On recognizing vacuum failure in IMC, transition to partial panel using the turn coordinator, compass, and pitot-static instruments.

17. C. ATC turn instructions — A no-gyro approach is valuable because the controller issues turn instructions the pilot executes with the turn coordinator, removing the heading-management burden.

18. A. Declare emergency — Vacuum failure in IMC warrants declaring an emergency and requesting priority handling and assistance.

19. A. Rate + coordination — The turn coordinator displays rate of turn and quality of coordination (the ball).

20. B. Independent attitude — A standby electric attitude indicator with its own battery provides attitude information independent of the vacuum system and main electrical bus.

21. D. Precesses/diverges — During a vacuum failure, the heading indicator precesses at an accelerating rate, diverging from the magnetic compass.

22. A. GPS or ILS — A partial panel approach is best flown with a GPS or ILS approach, which provide a course reference reducing heading-management workload.

23. D. Stable reference plane — Rigidity in space lets the attitude indicator maintain a stable reference plane against which pitch and bank are displayed.

24. C. Vacuum failure drift — An attitude indicator showing a bank not confirmed by the turn coordinator and compass indicates a vacuum failure causing it to drift.

25. C. Realistic/insidious/lethal — Vacuum failure is heavily tested because it is realistic in the vacuum-gyro fleet, its effects are insidious, and undetected failure has caused loss of control.