Initial Turbine Aeroplane Conversion: Briefing Notes

Chris R. Burger
chris@burger.za.org
V1.3

Table of Contents

1 Introduction

These notes are designed as guidance for instructors providing initial turbine-engined aeroplane conversions for pilots with considerable piston-engine experience. If the training aircraft is multi-engined, it is also assumed that the pilot has sufficient experience and understanding of asymmetric operations. If the pilot under training is lacking in any of these respects, additional training beyond that outlined in these notes must be included.

The notes emphasise differences, assuming as they do that the pilots are already conversant with relevant VFR and IFR operations. No attempt is made to elaborate on various topics; they only serve as a reminder for the instructor as to what should be covered. Hollow bullets are used to enable the instructor and student to mark off topics as they are covered.

The notes are general in nature, and are not restricted to any one type or group of types. More specific reference should be made to the characteristics of the training aircraft.

Air exercises cover all CAA requirements for type ratings as of early 2003. A type rating checklist can be found on the CAA Web site.

Thanks to Peter Clark, Francois Naudé and Craig Pearce for their inputs!

Recommended reading:

- *The Turbine Pilot's Flight Manual*, Brown/Holt, Iowa State Press. The first edition is adequate, but the second edition offers a wealth of useful operational guidelines and rules of thumb.
- The Pilot's Flight Manual and technical manuals for the specific training aeroplane must also be available for reference.

2 How turbine engines work

2.1 Basic gas turbine

- Compressor, turbine, terminology (T_N, P_N, ITT, EGT, JPT), stations, axial vs. centrifugal flow.
- Four stroke analogy (ICPE).
- Multi-spool engines, multi-stage compressors/turbines.
- Accessory gearboxes.

2.2 Jets vs. fan engines

- Bypass ratio.

2.3 Power turbines

- Free vs. direct-drive. Discuss noise level during idle, prop feathering at shutdown, relative efficiency. On direct drive: Inertial coarse pitch stop to prevent feathering on shutdown.

2.4 Reverse thrust

- Propeller reversal.
- Clamshell, cascade, petal doors.

2.5 Other subsystems

- Autofeather.
- Negative Torque Switch to detect windmilling (direct-drive turbines).
- Shutdown: Residual fuel in fireproof cans, pneumatic ejectors to pump fuel into turbine at shutdown.

2.6 Reverse-flow engines (e.g. PT6A)

- Modular construction.
- Advantages in maintenance, exhaust flow direction (for single-engined aeroplanes), ice separation (reversal of flow direction at input).

3 Differences between turbine and piston powered aeroplanes

3.1 Engines

- **Power delivery:** More constant power delivery, rather than pulsed. Quadratic relationship between power lever and power, rather than linear.
- **Vibration levels:** High frequency vibration vs. low frequency. Lower noise levels, except due to exhaust turbulence. Old vs. new engines (e.g. jets). Lower noise level on fan engines (due to reduced shear gradient).
- **Reliability:** Fewer moving parts, no gyration. Typical TBOs.
- **Altitude behaviour:** Less reduction in power with altitude due to derating (same can be achieved with turbochargers). Much more fuel efficient at altitude.
- **Fuels:** Flexible (Avtur, Avgas etc.).
- **Power/mass ratio:** Far superior. lb/HP comparison.
- **Monitoring:** Less direct pilot feedback (noise, vibration).
- **Time lag:** Takes time to spool up.
- **High idling speeds:** Need for beta, reverse thrust, noise protection.
- **Systems:** Starter/generator, bleed-powered pneumatics/hydraulics/vacuum.
- **Residual jet thrust:** EHP in turboprops.

3.2 Environmental

- **Higher altitudes:** Low pressures, low density, low temperatures.
- **Pressurisation:** Generally bleed air with outflow control, heat exchangers, vapour cycle cooling. Otherwise electric pumps.
- **Air conditioning (heating and cooling):** On ground and in flight. Electric, bleed air, air cycle, vapour cycle.
- **Instruments and controls:** Cabin altitude, pressure difference, rate, dump.

3.3 Ice protection

- **Engines:** Fuel freezing, ice ingestion. Oil/fuel heat exchangers, electrical heaters, deflectors. Effects on power delivery.

- **Airframes:** Leading edges, instruments (pitot/static). Electrical heating, pneumatic boots, minimum speeds, maximum speeds (windshield icing).
- **Anti-icing vs. de-icing:** Differences.

3.4 Airframe handling

- **Higher speeds:** Transonic problems, poor low-speed characteristics, sweepback.
- **Tighter performance margins:** Takeoff, landing, climb profiles, fuel planning i.t.o. altitude.
- **Weight and balance:** Wider range. Standard passengers, random loading.

3.5 Systems

- **Flight controls:** Spoilers, leading edge devices, speed brakes.
- **Annunciators:** Red, Yellow, Green, Master warning.
- **Avionics:** More weather avoidance equipment, more complex (HUD, TCAS etc.).
- **Squat switches:** Pressurisation, spoilers, anti-ice, thrust reversers, nosewheel centering.

3.6 Human factors

- **Multi-crew:** Communication, interaction, assertiveness.
- **Physiological:** More hostile environment, emergency descents, TUC.
- **Higher speeds and altitudes:** Higher workload, more requirement for planning, nastier weather, more wind effect.
- **High workload:** CFIT problems.

4 Handling of turbine engines

4.1 General characteristics

- Less sensitive to power changes and temperature considerations (e.g. CHT). Can go from idle to full power and back again with no ill effect.
- More susceptible to mishandling i.t.o. parameter exceedance, bad starts etc.
- Greater time lag than typical piston engines. Requires more planning and anticipation with power changes.

4.2 Engine controls

- **Jet engines:** Thrust lever, reverser.
- **Turboprop:** Condition lever, propeller lever, power lever. Reverse, beta, governing range.
- **Instruments:** ITT, N_1 (N_G), N_2, EGT, EPR, JPT.

4.3 Power changes

- Remember time lag and quadratic relationship. Consider speed/attitude and power/descent rate relationship (long vs. short time constant).

4.4 Turboprop handling

- **Power changes:** Sequence in PFM (*power-pitch* for King Airs!). Consider top-up of power lever after workload is taken care of.
- **Reverse thrust:** Remember to place in full fine pitch before landing. Remove at low speed (blade erosion, FOD, visibility).
- **Sudden changes:** Massive drag when pitch is flattened.

4.5 Simulating engine failures

- **Techniques:** Condition lever, power lever, fuel cutoff etc. Zero thrust settings.
- **Effect of yaw damper:** Desirability of yaw damper in various phases of flight.
- **Effect of autofeather:** Handling of power lever in engine failure.
- **Raisbeck Magicam:** Handling during engine failure.

5 Starting turbine engines

5.1 Basic technique

- **Before:** Check battery voltage, pre-existing engine temperature. Consider winding first, external power.
- **Start:** Wind to specified N_G, add fuel and ignition, monitor temperatures.
- **Abort** *quickly* if start goes wrong. Could consider re-starting if N_G behaves.

5.2 Starting problems

- **Hot starts:** Generally due to inadequate N_G. ITT goes out of range. Very short time constant. Abort by interrupting fuel supply. Keep winding.
- **Hung starts:** N_G does not increase according to plan. Could have high ITT. Cut off fuel, continue winding. Could re-introduce fuel if N_G comes into range. Often due to tailwind, low N_G. Often accompanied by growling noise.
- **Wet starts:** No ignition. Turn off ignition, continue winding to remove extra fuel before re-ignition.

Note: Low battery conditions tend to be closely associated with starting problems. The low battery makes it hard to wind the engine sufficiently energetically, and ignition is also often not energetic enough.

6 Adapting to turbine operations

6.1 Checklist usage

- Flow checks, do-lists, checklists
- Recall items

6.2 Adapting existing checklists

Existing procedures (suitable for piston-engined aeroplanes) can be adapted for use with turbine engines. The most common problems are associated with power handling and environmental systems.

The existing SAAFI checklist can be simply adapted as follows:

- Whenever *Pitch* or *Propeller* appears, remember to also check propeller synchronisation and autofeather.
- Remember that, in turboprops, a power increase should generally be made with power lever first (i.e. don't first slam the prop lever to full fine pitch—you will probably be stopped in your tracks!).
- After takeoff and before landing checks end with "Cowl flaps". Just add "Cabin" to the checklist at this point, to remember to take care of pressurisation issues.
- The sequence of flap and undercarriage operation is often reversed for larger aircraft, as the influence of undercarriage on performance is less marked than that of flaps.
- Use the aircraft's written checklist to verify that the recall items have all been taken care of.

7 Air exercises

7.1 Familiarisation with aircraft

- Systems, technical.
- Panel layout (use paper cockpit).
- Touch drills for all normal and emergency procedures.

7.2 Normal handling

Climb, descent, high altitude, environmental system, autopilot, yaw damper, ice protection, trim vs. configuration, descent into circuit, takeoffs (normal, flapless, short), landings (normal, flapless, short, crosswind), approaches (ILS, auto-coupling).

7.3 Abnormal handling

Asymmetric handling, V_{CRIT}, stalling, low speed flight, turbulence, emergency descent.

7.4 High altitude handling

Control response, limiting bank, high Mach numbers, cruise configurations.

7.5 Emergency drills

Fire, smoke, pressurisation problems, engine shutdown, unfeathering and relight, hydraulic failures, electrical failures (generator, regulator, inverter etc.), engine failure before/at V_1, single-engine landings, single-engine go-around.

7.6 Night flying

Normal operations, single engine overshoot, single engine landing.