Flight Test Society of South Africa

Flight Test Report
Focke Wulf Piaggio P149D-TP

IASSA 2015

Des Barker

Scope

- Executive Summary of Flight Test Programme:
  - Background
  - Objectives of Test Programme
  - Scope of Modifications
  - Flight Test Team
  - Conditions Relevant
  - Results and Discussion
  - Conclusions
  - Recommendations
  - Lessons learned and observations

Background

- Designed, developed by Piaggio & Co, Italy, 1953.
- Licence built Focke Wulf: Basic trainer + light utility.
- Retired 1970 from Service.
- Acquired and imported into RSA Werner Heiml.
- Flight test NTCA 2013.

From This!

To This!!

Objectives

To demonstrate the modified *Piaggio P149D TP* aircraft's compliance with the requirements of Part 24 of the CAR's and certain applicable requirements of *FAR-23 Subpart B: Flight*.

The aircraft is a Non-Type Certificated Aircraft (NTCA) Ex-Military in terms of Part 24 of the SA Civil Aviation Regulations (CAR's).

Proving Authority. The P149D aircraft with registration ZU-SFP (S/N 0060) was operated with a Proving Flight Authority issued by the SA Civil Aviation Authority. ZU-SFP was assigned as the prototype test aircraft.

Aircraft Modifications

Basic Autopilot

O_2 System

- Dorsal Fin
- Canopy
  - Lowered 125mm
  - Streamlined

– ‘Swooplets’

Fuel System
- Outboard
- Mid span
- Ferry Tank

Nose U/C

720 shp Walter 601D Turboprop vs 275 hp Lycoming GO-480
- New engine mounting 600 mm/CG
- Brackets & skin doublers
- FAR23.631 structural compliance = 3.8g

Cockpit Modifications

Walter 601D TurboProp

Walter M601D Engine

- designed for remote/rugged operations.
- minimal field maintenance requirements
- Maintenance between overhauls:
  - primarily filter and screen cleaning,
  - compressor wash,
  - oil change,
  - borescope inspection,
  - igniter replacement.
- "hot section inspections" between overhauls not required.
- Recommended (TBO) defined by "cycles“
  - engine starts,
  - flight time, and
  - calendar time.
- TBO interval 2,250 to 20,000 cycles (depending service type/engine series),
- 1,500 to 3,000 hours flight time,
- 5 to 8 years calendar time between overhauls.

Cost Comparison
Walter RM1.2 vs PT-6 RM 3.5

Max. Continuous Rating	657 eshp
N_1 *(Gas generator)* **RPM** *(100%)*	36,293 rpm
Max. Propeller RPM	2080 rpm
Max. Inter-Turbine Temperature *(ITT)*	690°C
Equivalent Specific Fuel Consumption *(ESFC)*	0.648
Max. Fuel Consumption @ 657 eshp	65 gph
Cruise " " @ 350 to 400 eshp	35-37gph
Idle " "	25 gph
Weight *(dry)*	425 lb
Height/width/length *(inches)*	26"-23"-66"

Aeromechanical Implications

- Mass Re-distribution. Static margin maintained for standard Piaggio P149D = propeller mounting face forward by 305mm (12 inches).
- Static Margin. Net effect = mass redistribution with static margin theoretically unchanged; pitch/yaw inertial moments impacted on the static and dynamic stability characteristics of the aircraft.
- Inertial Effects. Increased propeller mass increased rotational inertia by 26% - although rotational speed essentially same as Lycoming, propeller gyroscopic loads changed.
- Power Effects. Walter 601D maximum power 2.5x greater than Lycoming GO-480
  - double propeller/engine torque
  - increased helical airflow around fuselage
  - static and dynamic stability characteristics of the aircraft changed.
- Aircraft Performance. 32% increase in shaft horse power significantly increased aircraft performance, viz SEP ie takeoff, climb, acceleration, sustained turn pfx.
- Stability and Control. Increased shaft horse power significantly increased slipstream, downwash, and mass flow – determine in flight test.

Test Programme Management Team

Test Pilot Class I. Des Barker, military (SAAF) experimental test pilot - 56 types: Piaggio P149 D, total flying hours 7020. 20 hours on Walter 601D turboprop engine and 430 hours Pratt & Whitney turbo-propeller engines.

Test Pilot CAA Class II. Mr Neil Thomas - 30 types: Piaggio P149D, total flying hours 6000. 80 hours experience on Walter 601D turboprop engine + 1300 hours on Pratt & Whitney turbo-propeller engines.

Aircraft Maintenance Organisation. Mr Johan Lok, (Warbirds, (Pty) Ltd).

Flight Test Management. The flight test programme was managed by the programme manager through a Safety Review Board (SRB). The SRB comprised following members:

1. Class I Test Pilot.
2. Class II Test Pilot.
3. Aircraft Maintenance Engineer.
4. CAA Certification representative.
5. Each flight planned + flight test card prepared prior to flight.
6. Hazard analysis conducted per flight – risks minimized through procedure or actions.

Conditions Relevant

- Aircraft Structural Limitations
  - Load factor: Nz = +3.8g. (Originally +6g/reduced to 3.8g in accordance with static load tests approved by CAA).
  - Negative load factor: Nz = -1.9g. (FAR 23 negative limit 0.5 x positive limit, i.e. n = -1.9g.
  - Retained:
    - Maximum speed: V_D = 204 KIAS.
    - MTOW (Normal Category): 1820 kgs.
    - Fwd CG limit: 0.42m.
    - Aft CG limit (Normal Category): 0.62 m.
- Mass and Balance. CG location each flight adjusted combination of long range fuel tank located aft and 30 kgs lead ballast located in baggage compartment.
- Test Schedule.
  - 7 July 2013 to 15 October 2014.
  - 54.9 hours flown; included 28 flight test hours and 10 owner conversion hours.
- Test Location. Wonderboom Airport, Pretoria, elevation 4095 feet, main runway 29/11, total distance 5996 ft asphalt surface.
- Air Traffic Control. Air Traffic Control and Fire/Emergency response provided by Wonderboom Airport.

Flight Test Programme

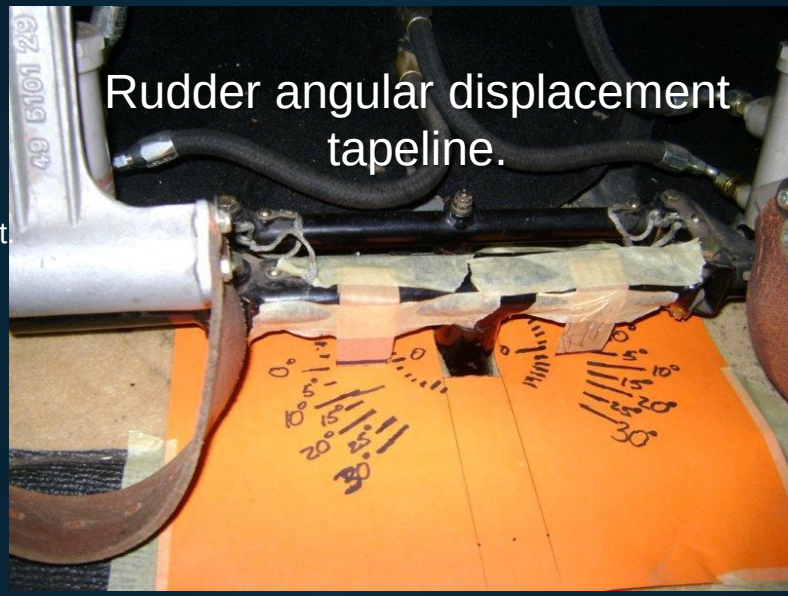
- Build-up to first flight
  - engine ground runs,
  - ground handling,
  - low speed and high speed taxi tests.
  - Build-up in torque vs handling qualities vs pilot workload.
- Airframe/engine structural inspections after every flight.
- Pitot/Static calibration.
- Engine In-Flight Relight.
- Stalling characteristics, level +accelerated flight (various flap/CG positions).
- Static and Dynamic Stability. Short Period Pitching Oscillation (SPPO)/Long period 'Phugoid'/-Longitudinal static stability.
- Lateral Directional. Dutch Roll/Spiral Stability/Steady Heading Sideslip.
- Manoeuvre Stability. Wind-up turns.
- Performance = Take-off /Climb performance/Level Cruise performance.

  Descent performance/Landing performance.

Flight Test Instrumentation

No automated flight test instrumentation was provided.
Test data manually recorded from aircraft's:

- Flight and engine instruments.
- Stick force gauge to measure stick forces
- Rudder forces estimated
- Sideslip strings to estimate sideslip angle.
- OAT
- Ballast – fuel and 30 kgs lead weights in baggage compartment



Structural Testing

Cradle tested to 2 limit loading cases required by FAR 23.361 and 23.363.

A turbine torque factor of 1.6 and a factor of safety of 1.5 were included in load calcs

Inspections on critical airframe structure viz

- Engine mountings.
- Horizontal tail mounting structure.
- Inspections repeated every 5 operating hours up to 25 hours.
- Structural inspections continued every 25 hours to 100 hours and thereafter during MPI's.

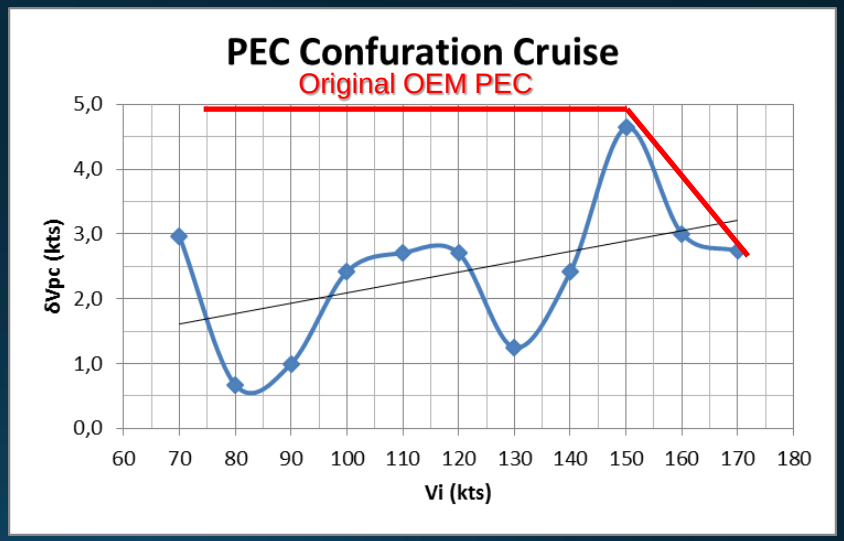
Mass & Balance

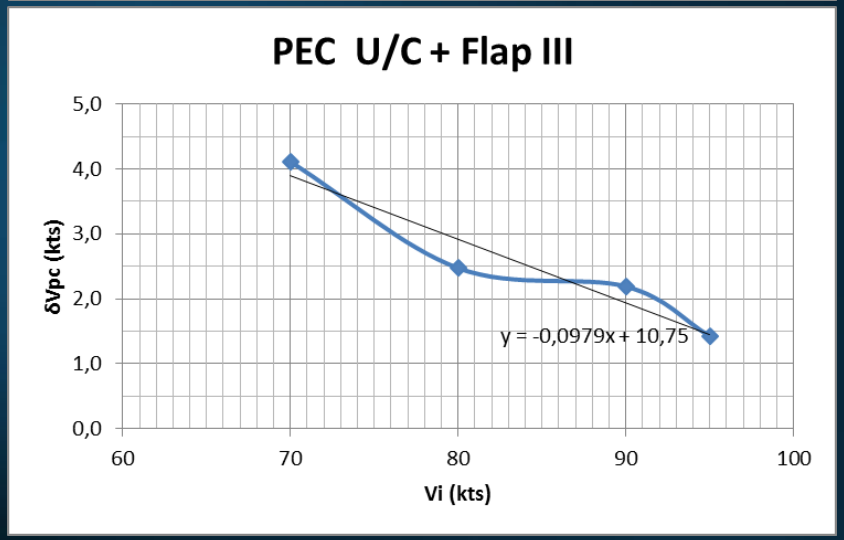
	MASS (kgs)
WEIGH DATA:	
Nose wheel	214,0
L/H main wheel	547,0
R/H main wheel	554,1
SUB TOTALS:	1315,1
Fuel inboard fwd tanks (max 68 kg)	68
Fuel inboard rear tanks (max 118 kg)	118
Fuel centre tanks (max 142 kg)	**0**
Fuel tip tanks (max 60 kg)	60
Fuel auxiliary tank (max 56 kg)	56
TOTAL FUEL LOAD:	302
Pilot	85
Co-pilot	85
Pax (max 2)	0
Baggage (max 70 kg)	30
	1817,1

MAXIMUM TAKE-OFF MASS 1820 kg

FLYING CG RANGE: 0.424 m to 0.622 m

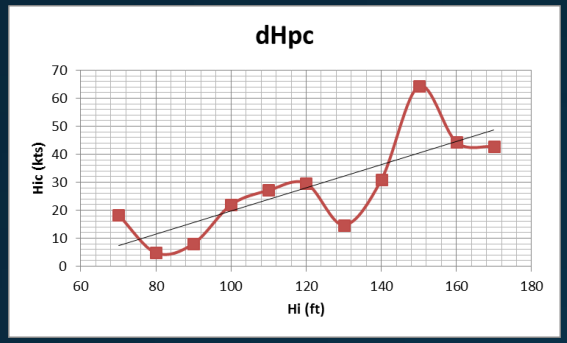
Pitot Statics – FAR 23.1323





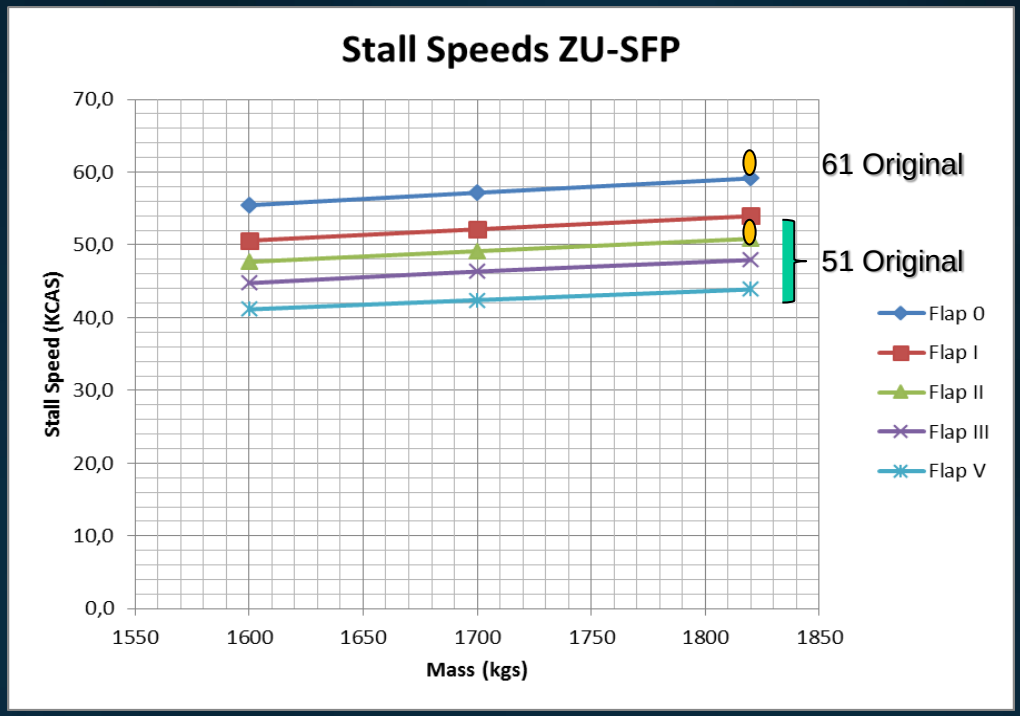
- Nose extended by 305mm (12 inches).
- Reshaped canopy effects on flow field in vicinity of static ports.

FAR 23.1323 = δV_{pc} < 3% or 5 kts, whichever greater from 1.3 Vs_1 to Vne



Stalling: FAR 23.207

- Must be a clear and distinctive stall warning, flaps and U/C in normal position, in straight and level and turning flight.
- Stall warning margin of not less than 5 knots and must continue until stall occurs.
- Stall warning of 2 KIAS unsatisfactory.
- FAR Part 23.207 Stall Warning, was not complied with.
- 61 KCAS promulgated in FAR 23.49.c in which Vso and Vs1 at maximum weight must not exceed 61 knots



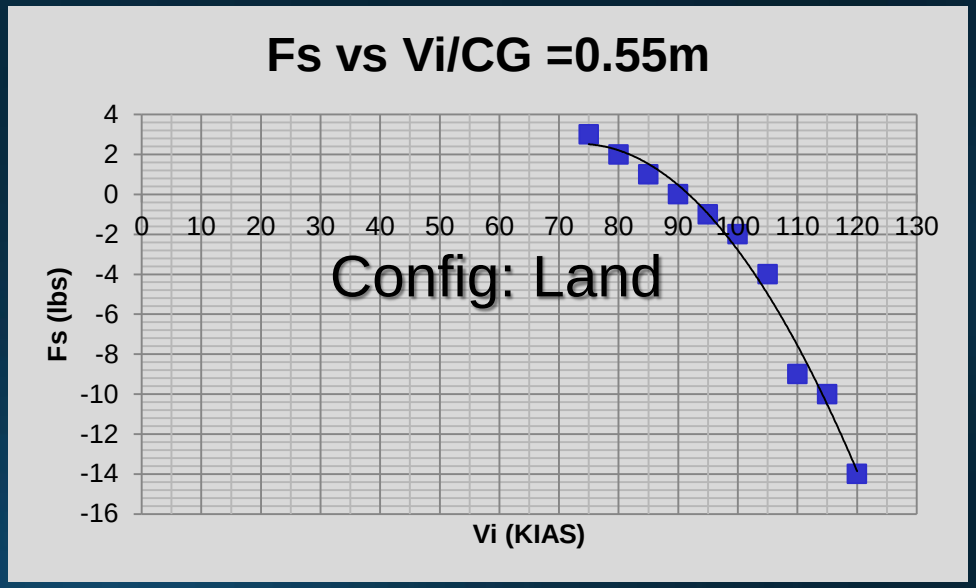
Stall speeds lower than Piaggio P149D ranging

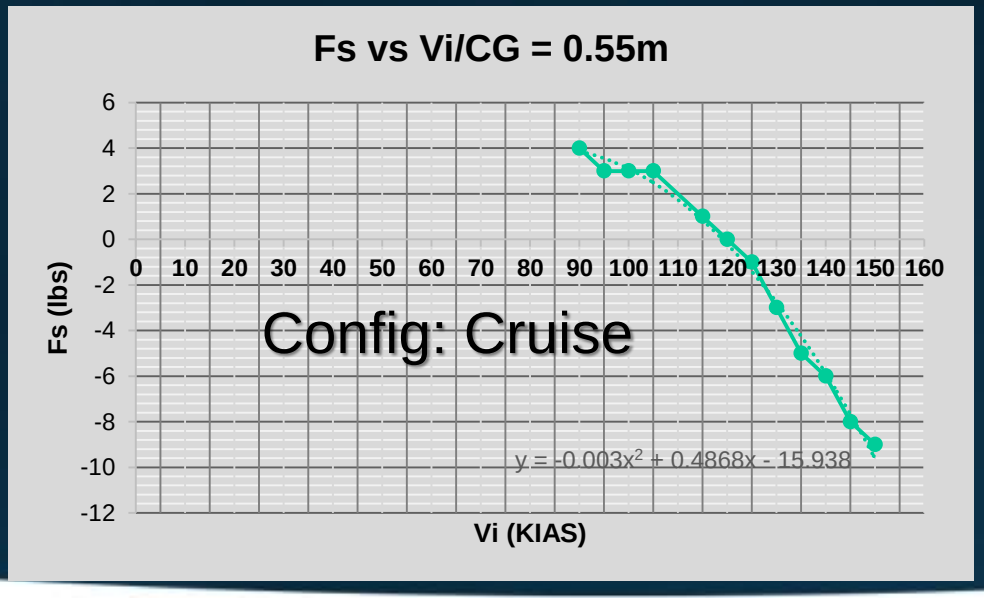
- 2 KIAS lower in cruise.
- 7 KIAS lower landing configuration (Clmax = 1.9)

Contributory causes considered to be

- *Cl* from increased mass flow
- 'swooplets'

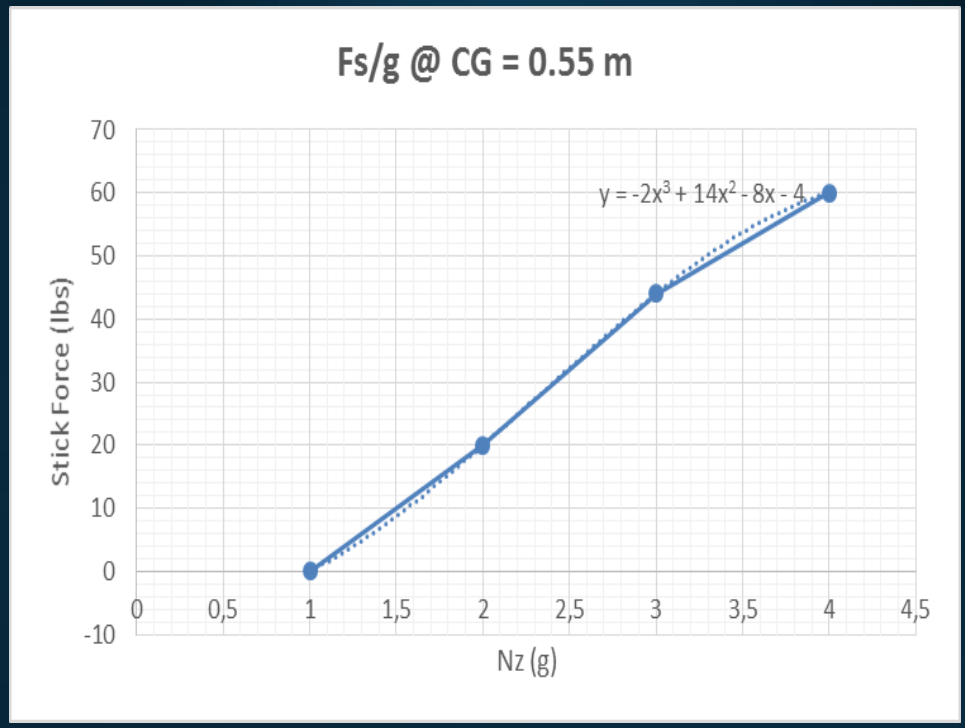
Longitudinal Static Stability: FAR Part 23.173





Manoeuvre Stability/CG = 0.55m

- Wind-up turns + pull-ups during accelerated stalls.
- Stick force/g increase linearly with increase in ‘g’
- Maximum 60 lbs/g at V_a of 160 KIAS/Nz = 4g gradient of 15 lbs per g.
- FAR Part 23, Sec. 23.155 Elevator Control Force in Manoeuvres was complied with



Minimum Control Speed

- Minimum control speed/maximum torque airspeed determination.
- Determine boundary between aerodynamic control power versus asymmetric torque effects.
- Test conducted at 5,000 ft pressure altitude (5690 ft density altitude);
  - F_r did not exceed 150 pounds.
  - Not necessary to reduce power of the engine to maintain control.
  - Aircraft did not assume any dangerous attitude.
  - Possible to prevent heading change of more than 20°.
- Configuration Cruise. DA = 5690 ft. Max torque 90 psi/100%/1970 RPM.
  - Vi = 65 KIAS - aircraft fully controllable about all axes
  - 4 units right rudder (50% of maximum)
  - 2 units right aileron trim.

- Configuration Landing.
  - 2 x Compressor blowback @ 60 KIAS/ 2 due to engine acceleration and unstable intake conditions.
  - Second attempt lower rate - aircraft controllable at 60 KIAS
  - Maximum right rudder
  - 1/2 aileron; rate of asymmetry controllable.
  - Recommended ‘wave-off’ minimum airspeed = 60 KIAS (15 KIAS margin/MAUW)
- Essential: pilots **NOT TO SLAM THE POWER LEVER OPEN** at low speeds/high angles of attack.

Trimmability: Landing Configuration

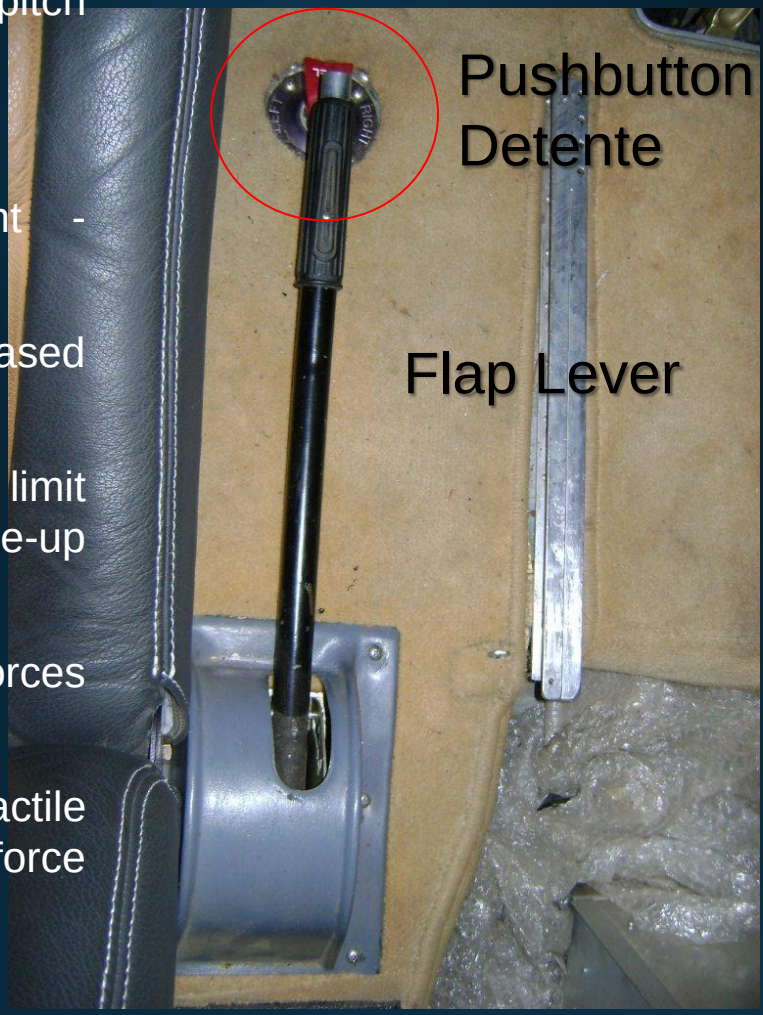
Insufficient trim authority to trim the aircraft in pitch with flap settings greater than Flap III.

- Effect of flap extension – CP moves aft,
- Increased nose-down pitching moment - requires nose-up trim.
- Decreased tailplane authority due to increased downwash.

Additional trim authority to maximum allowable limit setting provided by increasing the trim motor nose-up deflection.

Approaches >Flap III, residual stick forces approximately 8 lbs pull required for approach.

Unsatisfactory but acceptable; provided tactile feedback for landing flare without excessive pull force required.



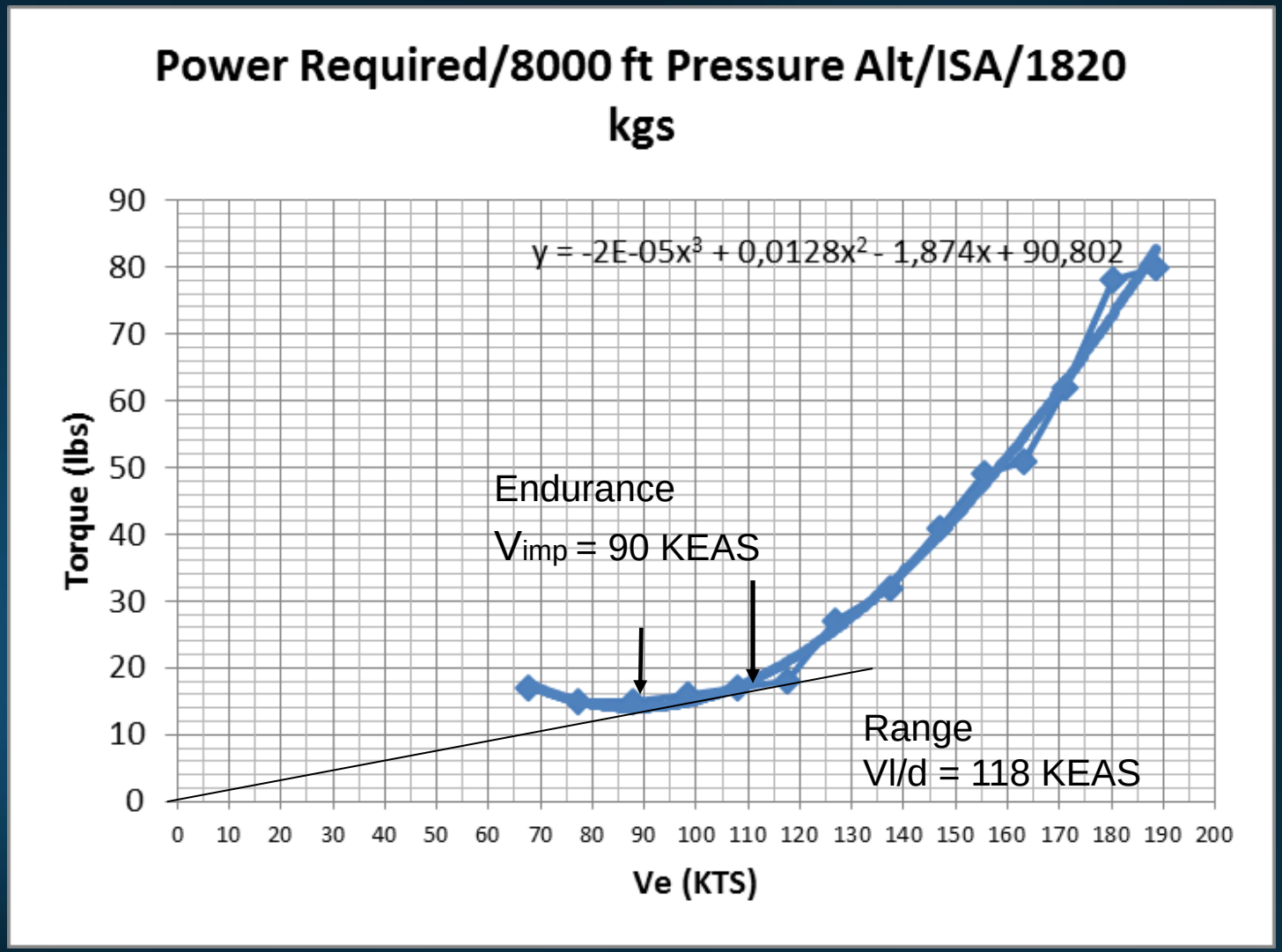
Performance Comparison MAUW 1820 kgs

Parameter	P149D	P149D TP
Takeoff Distance 50 ft (ISA +13°C)	2420 ft	**1180 ft**
Stall Speed (KIAS)	51	**45**
Crosswind Limit (kts)	20	**20**
Climb Time (mins) 5,000 ft – 10,000 ft	7.0	**2.0**
Ceiling (ft) ISA* (150 ft/min)	14,000	**21,000 (extrapolation)**
Power/Weight Ratio	0.14	**0.4**
Fuel Used in Climb	9.1 litres	**8 litres**
Descent Best Glide Speed (90 KIAS)	1.2 nms/1000 ft	**2.86 nms/1000 ft prop feathered**

SEP climb profile airspeed conversion rate of 10 KIAS per 1000 ft

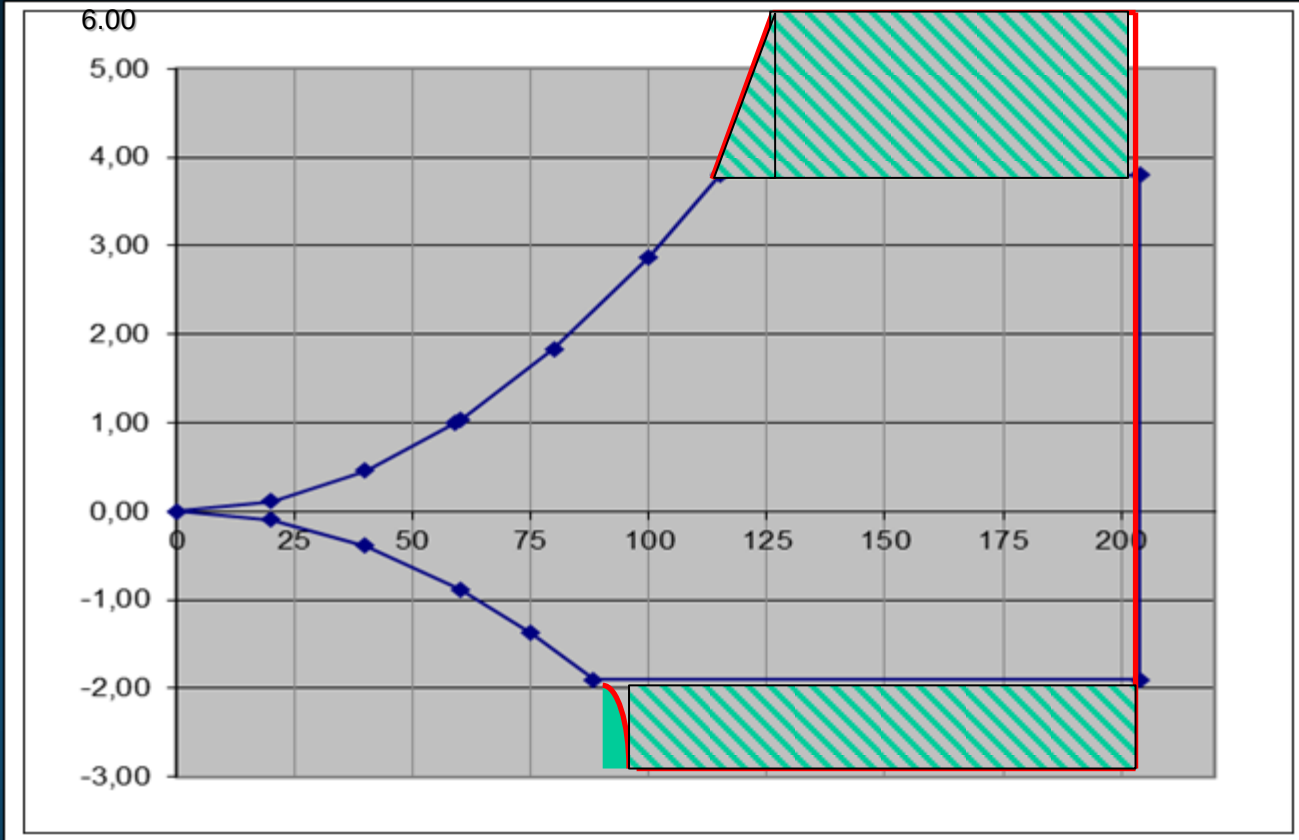
- average rate of climb 2542 ft/min +
- pitch attitude approximately 17°,
- high workload for the pilot.

Level Cruise Performance



Vn Diagram

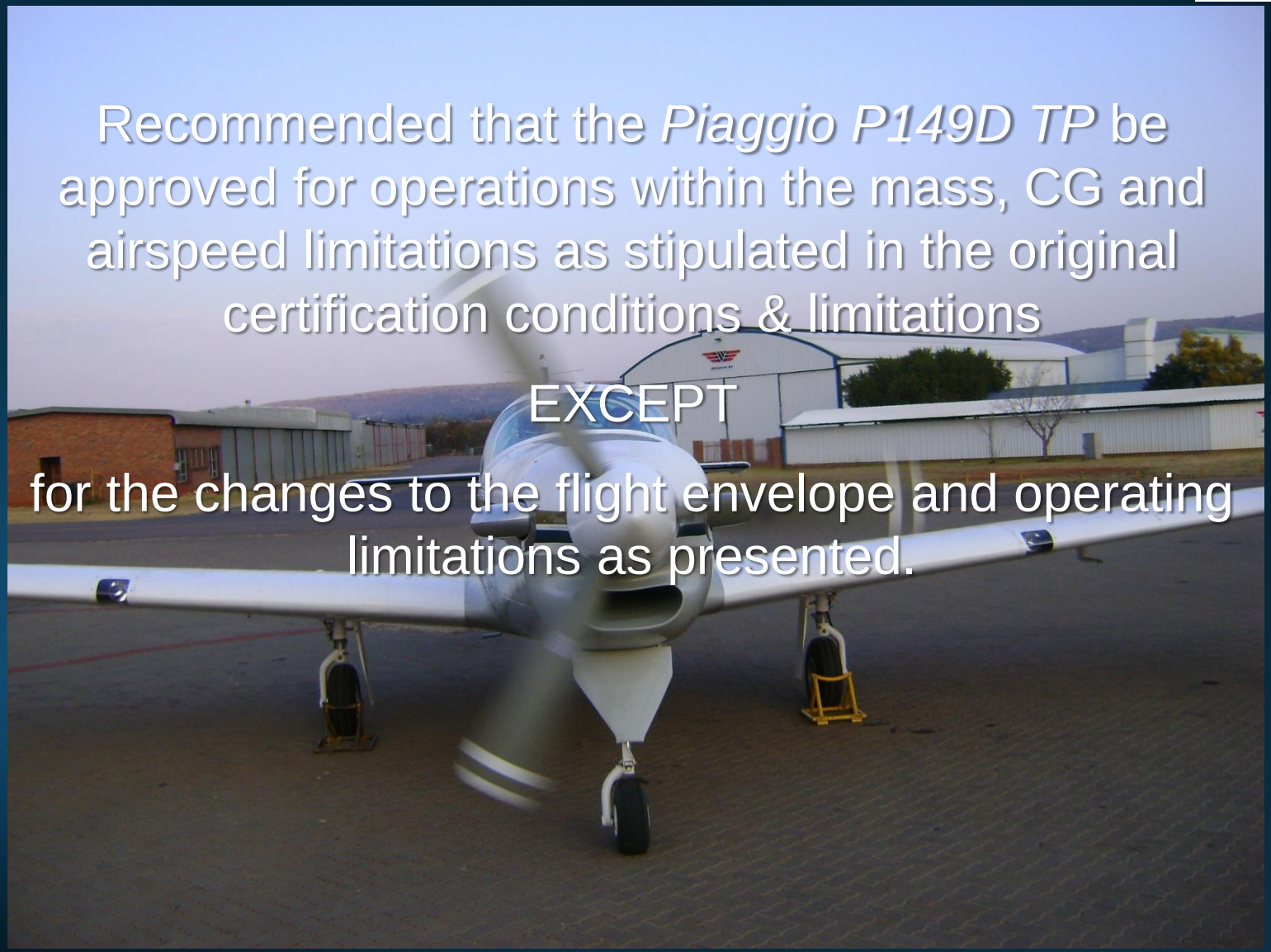
Nz



Vn diagram for *Piaggio P149D TP*.

Vi (KIAS)

Recommendations



Recommended that the *Piaggio P149D TP* be approved for operations within the mass, CG and airspeed limitations as stipulated in the original certification conditions & limitations

EXCEPT

for the changes to the flight envelope and operating limitations as presented.

Thank You!

The happy owner
Werner Heiml