PT6A
PILOT FAMILIARIZATION

August 2003

PRATT & WHITNEY CANADA

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INTRODUCTION

SCOPE

This training manual contains information pertaining to the specific operation of the PT6A engines.
This manual is intended for classroom use only. The following information reflects all that can be done on a pilot level to extend the engine life and reduce maintenance costs. P&WC understand that the pilots cannot make use of all the tips all the time. The information is provided as a guide only to a cost-effective operation. The pilot and its organization are responsible for evaluating which recommendations are applicable to their operation. A basic understanding of jet engine principles is recommended to attend this course.

ABBREVIATIONS

Ag	Agricultural (PT6A-15Ag)
AGB	Accessory Gearbox
AMM	Airframe Maintenance Manual
BOV	Bleed Off Valve
CCW	Counterclockwise
CSU	Constant Speed Unit (propeller governor)
CT	Compressor Turbine
CW	Clockwise
ECTM	Engine Condition Trend Monitoring
ESHP	Equivalent Shaft Horsepower
FCU	Fuel Control Unit
FI	Flight Idle (high idle)
FOD	Foreign Object Damage
GI	Ground Idle (low idle)
HSI	Hot Section Inspection
IAS	Indicated Air Speed
IBR	Integrally Bladed Rotor
ISA	International Standard Atmosphere
ITT	Interturbine Temperature (T5)
M/M	Maintenance Manual
MOP	Main Oil Pressure
MOT	Main Oil Temperature
Nf	Free turbine speed
Ng	Gas Generator speed
Np	Propeller speed
OAT	Outside Air Temperature
OSG	Overspeed Governor
P0	Bypass (spill) fuel pressure
P1	Fuel pump delivery pressure
P2	Metered fuel pressure
P2.5	Compressor (axial stage) discharge pressure (station 2.5)
P3	Compressor discharge pressure (station 3)
Palt	Pressure altitude
Pamb	Ambient air Pressure
PBA	Primary Blade Angle
PLA	Power Lever Angle
PPH	Pounds per Hour (lb/hr)
PSI	Pounds per Square Inch
PSIA	Pounds per Square Inch Absolute
PSID	Pounds per Square Inch Differential
PSIG	Pounds per Square Inch Gauge
PT	Power Turbine
Px	P3 pressure modified by a restrictor
Py	Px pressure modified by a restrictor
RGB	Reduction Gearbox
S/N	Serial Number
SB	Service Bulletin
SIL	Service Information Letter
SFC	Specific Fuel Consumption
SHP	Shaft Horsepower
SLTO	Sea Level Take-Off
T/O	Take-Off
T5	Interturbine Temperature (ITT)
TBO	Time Between Overhaul
Tq	Torque
Wa	Air mass flow
Wf	Fuel flow

COURSE SYLLABUS

PT6A PILOT FAMILIARIZATION TRAINING

Course duration 2 days (12 hours)
Classes 8:15 to 15:30
Breaks 15 minutes (at 10:00 & 14:00)
Lunch period 12:00 to 12:45

APPLICABLE TO
PT6A-11/15/21/27/28/34/35/36/112/114/121/135
PT6A-41/42/45/50
PT6A-60/61/64/65/66/67

STUDENT HANDOUTS
The appropriate training manual is given to each student.

COURSE OBJECTIVE
Provide pilots with information regarding normal and abnormal engine operation, operational procedures and tips on how to operate engine in a cost-effective manner.

NUMBER OF STUDENTS
25 max.

PILOT FAMILIARIZATION TRAINING

DAY 1
Introduction
Registration, orientation, video presentation

General information
Abbreviations
Features
Major Components
General Turboprop Operation
Engine Stations
Flanges and Bearings
Engine views (typical PT6A-40)

Engine Construction
- **Compressor Section**
  - Inertial Separator
  - Compressor Rotor Assembly
  - Compressor Bleed Valve
  - Cold Section Troubleshooting
- **Hot section**
  - Combustion and Turbine Section
  - Hot Section Troubleshooting
- **Gearboxes**

Oil System

Secondary Air System

Engine Indicating System
- Temperature Indicating System (ITT)
- Torque System

DAY 2
Ignition System

Performance
- Performance Check
- Engine Condition Trend Monitoring
- Operating Limits

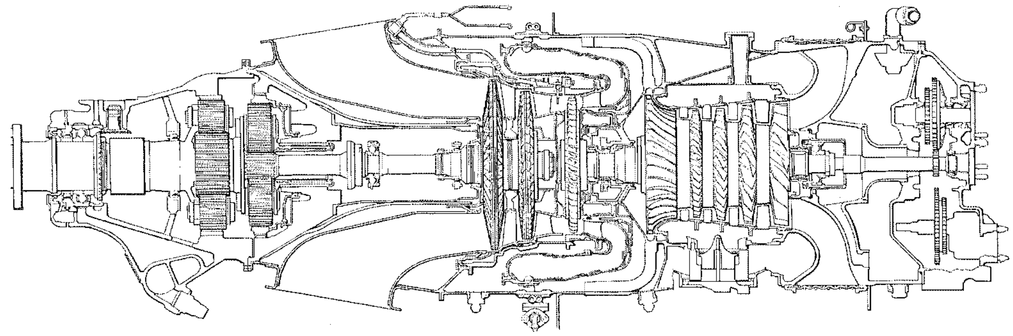
Fuel System
- Power management
- Fuel System Schematic
- Fuel Control Manual Override
- Overtorque limiter / Controller

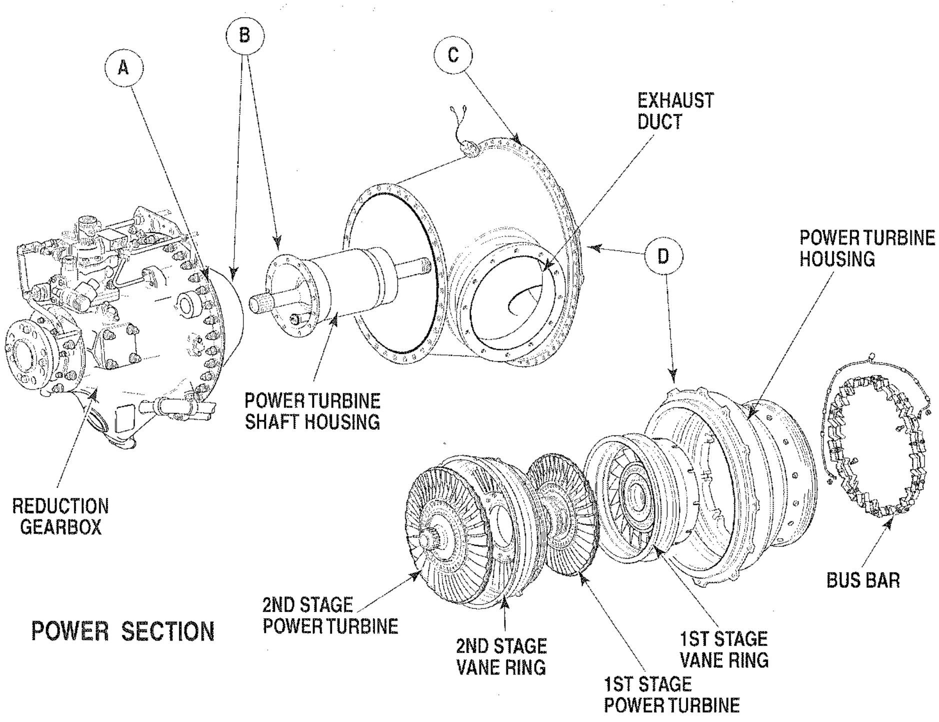
Propeller system
- Propeller Pitch Mechanism
- Propeller Governor
- Propeller and Power Turbine(s) Overspeed Protection

Engine Operation
- Cockpit lever settings
- Power Management, Common Sense Approach
- Engine Rating Philosophy
- Metal Versus Temperature

Special Application

EXAM
There is no examination required for pilot familiarization




A
B
C
EXHAUST DUCT
D
POWER TURBINE HOUSING
POWER TURBINE SHAFT HOUSING
REDUCTION GEARBOX
BUS BAR
2ND STAGE POWER TURBINE
POWER SECTION
2ND STAGE VANE RING
1ST STAGE VANE RING
1ST STAGE POWER TURBINE

CHAPTER 1
ENGINE OVERVIEW

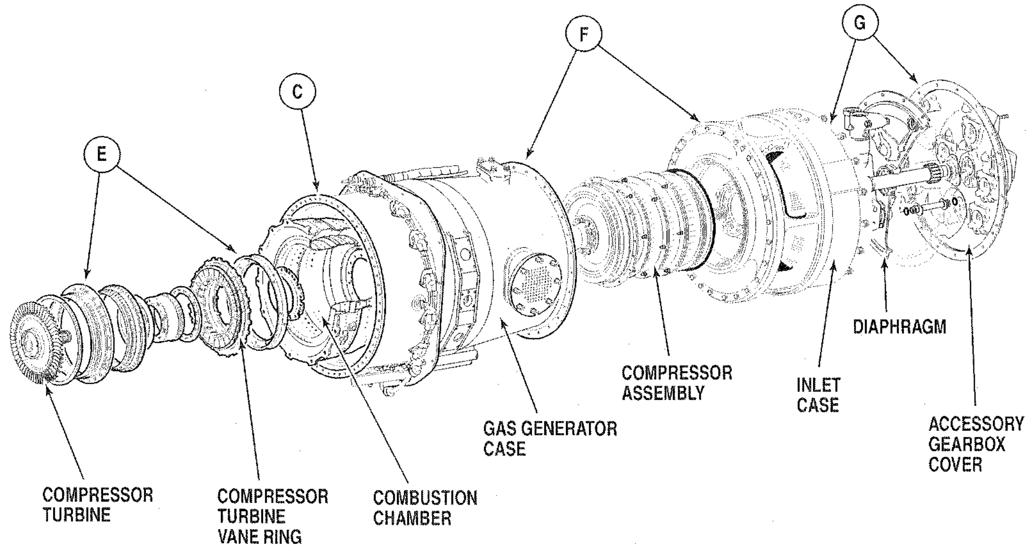
FEATURES

- 500 to 1650 shp
- Free Turbine Design
- Reverse Flow Combustion System
- Two Modules*: Gas Generator & Power Section
- Two Stage Planetary Reduction Gearbox
- Hydraulic Torque Measurement System
- Hydro-Pneumatic Fuel Control Unit
- Variable Speed Propeller
- Reverse Thrust Capability
- Two Or Three Lever Power Management
- Fuel Control With Manual Override **
- Torque Controlling / Limiting Device **
- Reserve Power Capability **

Notes:

* The PT6A-66 on the Piaggio Avanti has a third module which is the Reduction Gearbox Module.

** On certain models only.



GAS GENERATOR SECTION

GENERAL TURBOPROP OPERATION

The PT6A is a lightweight turbine engine driving a propeller via a two-stage reduction gearbox. Two major rotating assemblies compose the heart of the engine. One assembly consists of the compressor and the compressor turbine; the other consists of one or two power turbines and the power turbine shaft. The two rotors are not connected together and rotate at different speeds and in opposite directions. This design is referred to as "**Free Turbine Engine**". This configuration allows the pilot to vary the propeller speed independently of the compressor speed.

Starter cranking torque is low since only the compressor is initially rotated on start. Activating the starter mounted on the accessory gearbox starts the engine. The compressor draws air into the engine via an annular plenum chamber (inlet case), increases its pressure across the axial stages (3 or 4 depending on the model) and one centrifugal impeller and delivers it around the combustion chamber.

Air enters the combustion chamber via small holes and, at the correct compressor speed, fuel is introduced into the combustion chamber. Two spark igniters located in the combustion chamber ignite the mixture. The hot gases are then directed to the turbine area.

At this point, the ignition and starter are turned off since a continuous flame now exists in the combustion chamber. The hot expanding gases accelerate through the compressor turbine vane ring and hit the turbine blades which creates a rotational movement of the compressor turbine to drive the compressor. The expanding gases travel across the power turbine(s) area and provide rotational energy to drive the propeller shaft.

The reduction gearbox reduces the power turbine(s) speed (approximately 30,000 RPM) to one suitable for propeller operation (from 1210 to 2200 RPM depending on the engine model).

Gases leaving the power turbine(s) are expelled out to the atmosphere by the exhaust duct.

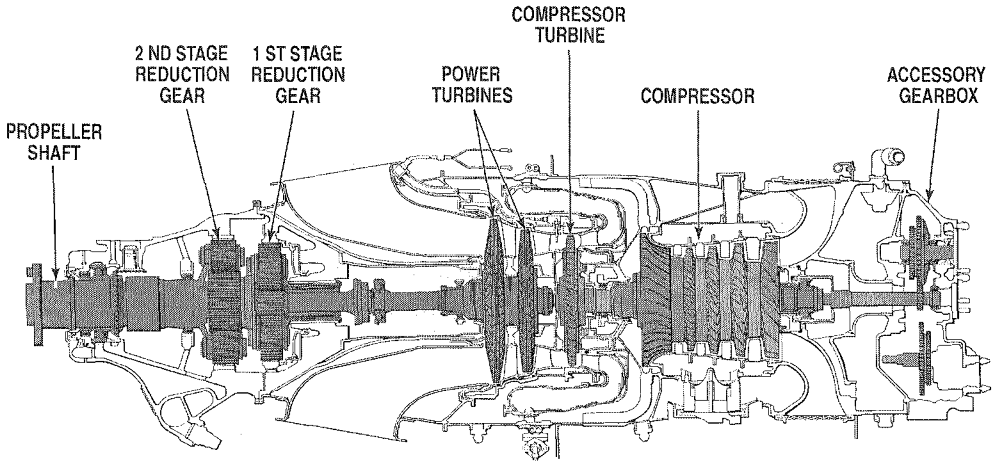
Engine shutdown is accomplished by cutting fuel going to the combustion chamber.

An integral oil tank located between the inlet case and the accessory gearbox provides oil to bearings and other various systems, such as propeller and torque systems.

A hydro-mechanical fuel control unit mounted on the accessory gearbox regulates fuel flow to the fuel nozzles in response to power requirements and flight conditions.

The propeller governor (CSU), mounted on the reduction gearbox, controls the speed of the propeller by varying the blade angle depending on power requirements, pilot speed selection and flight conditions.

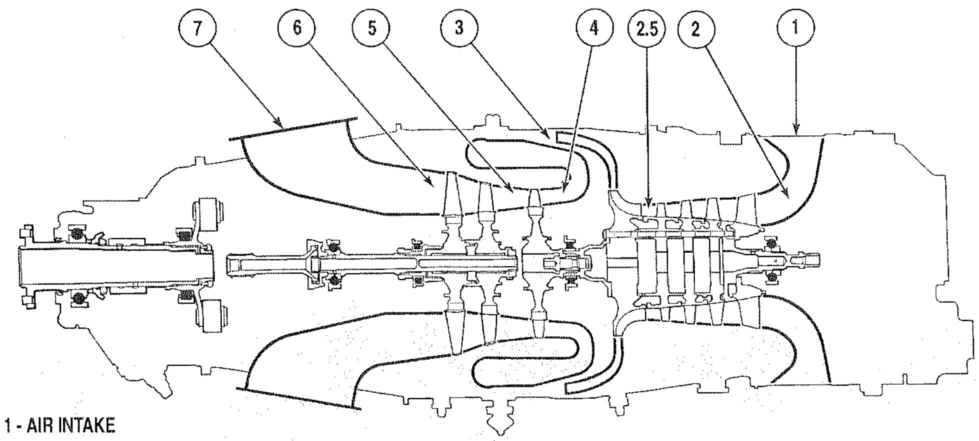
PT6A-67 ENGINE MODEL



STATIONS

STATION	LOCATION	TEMP. °C	PRESS. PSIA
1	Ambient	15°	14.7
2	Compressor inlet	16°	14.7
2.5	Interstage compressor	110°	26.4
3	Compressor discharge	280°	103
4	Turbine inlet	934°	101
5	Inter turbine	690°	35
6	Turbine exit	565°	16
7	Exhaust	551°	15.5

NOTE: Temperatures and pressures at take-off power (15°C and at sea level) for a small PT6A.



1 - AIR INTAKE
2 - COMPRESSOR INLET
2.5 - COMPRESSOR INTERSTAGE
3 - COMPRESSOR DISCHARGE PRESSURE
4 - COMPRESSOR TURBINE INLET
5 - INTERTURBINE
6 - TURBINE EXHAUST
7 - EXHAUST OUTLET

FLANGES & BEARINGS

FLANGES

Mating faces where components are joined together.

A. Attaches the Reduction Gearbox (RGB) front & rear housings to the exhaust case.

B. Attaches the RGB rear housing to the No. 3 bearing housing.

C. Attaches the exhaust case to the gas generator case.

D. Attaches the Power Turbine vane assembly to the RGB rear housing to the exhaust.

E. Joins the CT vane assembly together.

F. Attaches the inlet case to the gas generator case.

G. Attaches the AGB to the inlet case.

BEARINGS

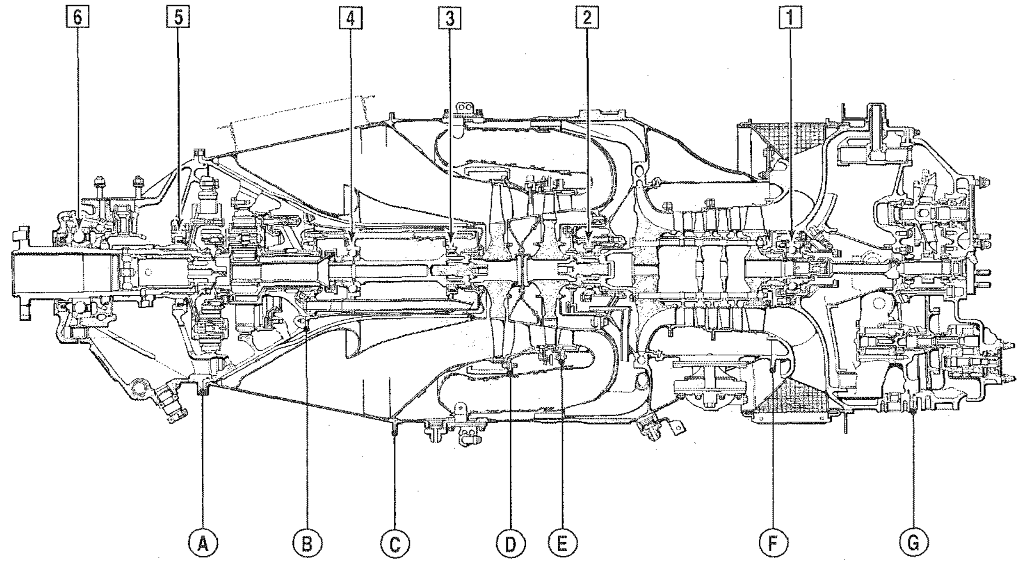
They support the major rotating assemblies. There are six or seven (for A-45/50/60/65/67 model) main bearings on the PT6A engine: three (or four) roller bearings and three ball bearings. The ball bearings withstand the following thrusts:
- No. 1 bearing:Compressor thrust (rearward)
- No. 4 bearing:Power turbine thrust (forward)
- No. 6 bearing:Propeller thrust (forward)

Bearings number 2, 3, 5 and 7 are roller bearings. They support radial loading and permit axial rotor movement required for thermal expansion.

ROTOR	SUPPORTED BY
Compressor shaft	No. 1 Ball
	No. 2 Roller
Power turbine shaft	No. 3 Roller
	No. 4 Ball
Propeller shaft	No. 5 Roller
	No. 6 Ball
	No. 7 Roller (if applicable)

Maintenance:

None on the bearings. Preventive maintenance consists of periodic oil level checks and inspection of filter. Ensure oil pressure is kept within limits.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5
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A
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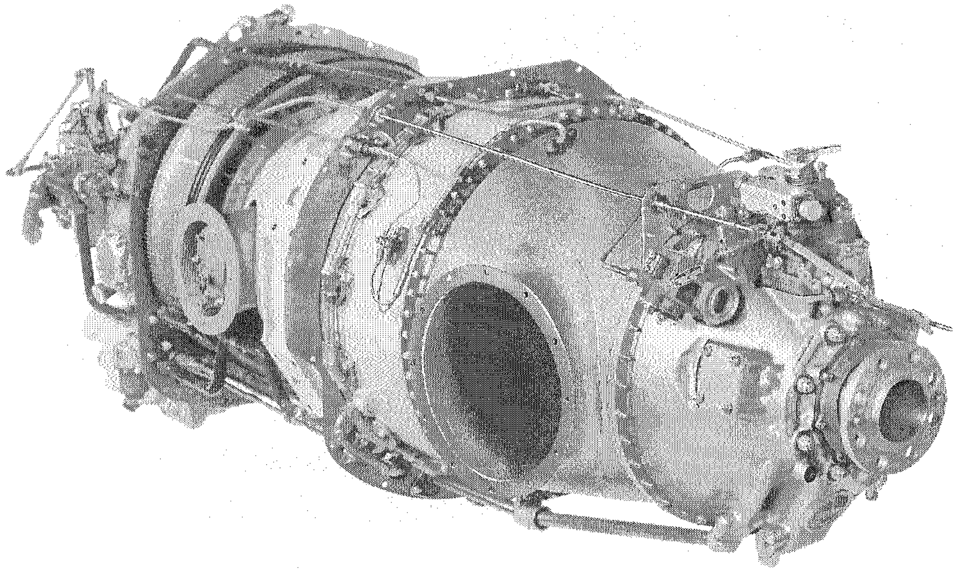
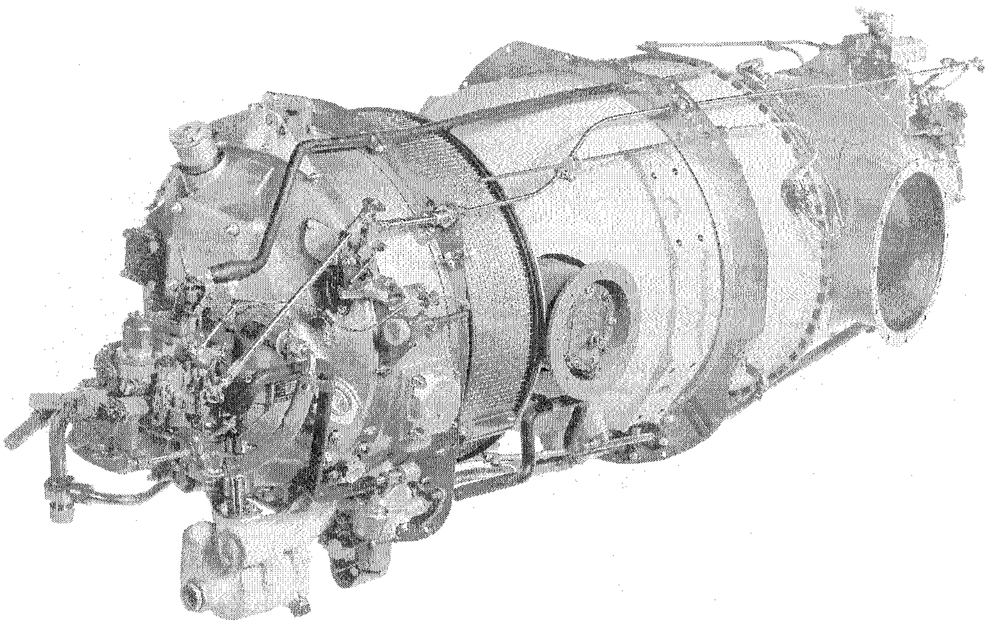
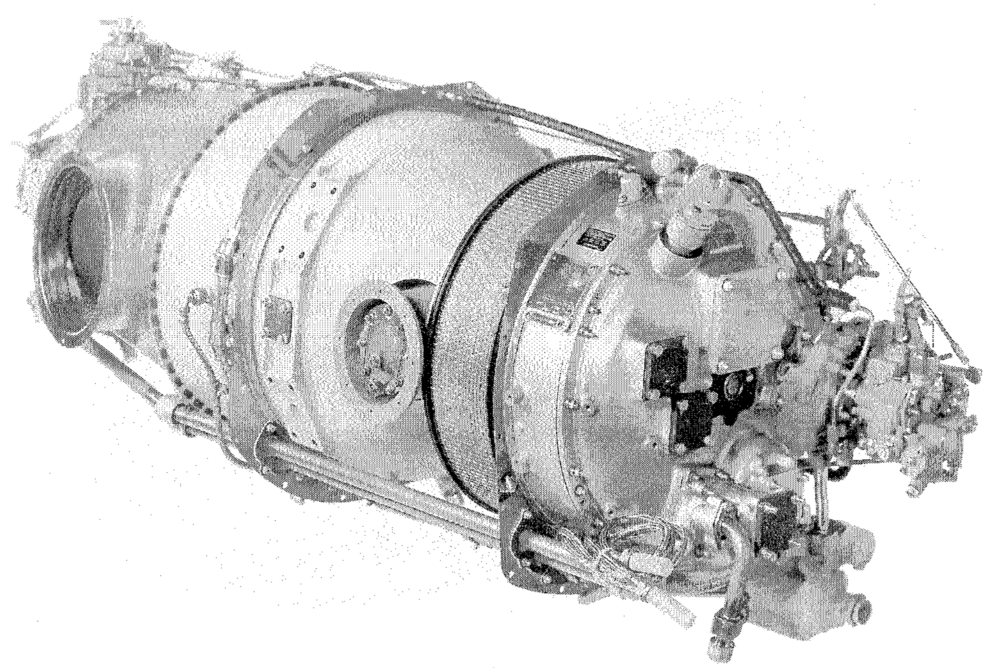
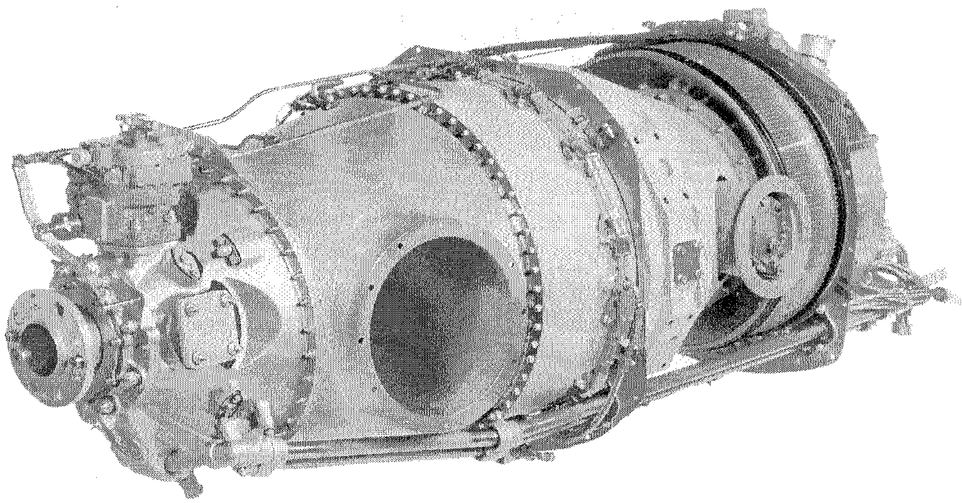
G









CHAPTER 2
COMPRESSOR SECTION

INERTIAL SEPARATOR (AIRFRAME)

Function:
Protects the engine from ingesting foreign objects such as stones, ice, sand, snow, rain, etc.

Operation:
Deployment of the inertial separator to the bypass (icing) position forces air in the nacelle to execute a sharp turn before entering the engine. Water droplets, ice crystals or snow, because of their inertia, tend to maintain their original high velocity path and are discharged overboard through the separator bypass duct.

Notes

- The inertial separator is an airframe-supplied item. Not using the inertial separator in icing conditions could result in costly damage to the compressor blades. Ensure the separator operates freely. Erratic movement of the separator vane may cause engine parameter fluctuation. For specific maintenance action, refer to the Airframe Maintenance Manual.

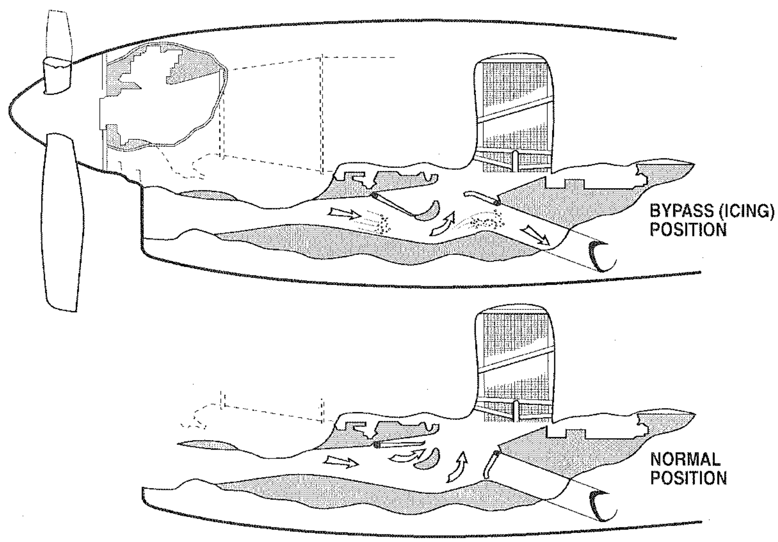
- When carrying-out a performance check, always ensure that the inertial separator doors are in the **CLOSED** position (non-icing). Inertial separator doors left in the open position will cause an increase in Ng, ITT and Wf which could be interpreted as a deteriorated compressor.

Pilot's tip

- It is very important to use the IPS (inertial particle separator) when operating the engine in an environment with visible moisture, in icing conditions or anytime there is a possibility of ingesting foreign debris into the engine intake to avoid cumulative damage to the compressor components (FOD). Not using it will lead to major and costly repairs.

FOD Prevention

- Use inertial separator during taxi operation and icing condition
- Check that tarmac is clean during walk around
- Avoid taxiing near construction area
- Avoid dropping safety wire or rivets in the air inlet plenum area
- Do not use reverse thrust at low ground speed
- What damages the propeller damages the compressor as well



COMPRESSOR ROTOR ASSEMBLY

Function
Provides the combustion chamber with the correct airflow at the required pressure and supplies pressurized air for aircraft pneumatic needs.

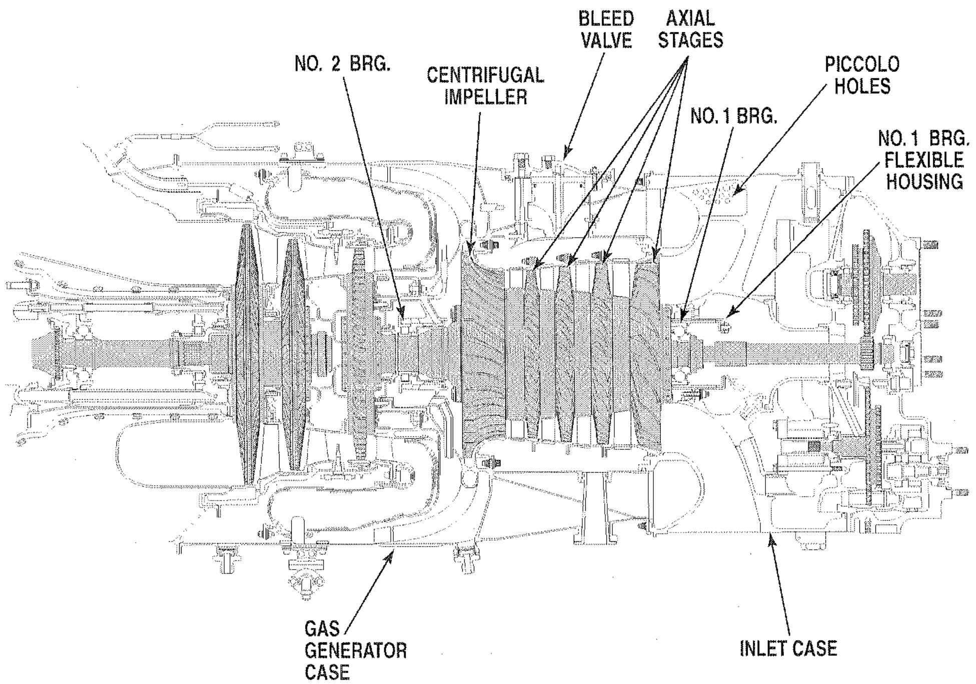
Construction
- Three or four axial rotors, which may be bladed assemblies (titanium on the first stage and stainless steel on the others) or IBR's (integrally bladed rotor) (titanium) and a centrifugal impeller (titanium).
- The rotors are held in place with tie rods that extend through the compressor stages.
- Stator vanes are mounted after each axial rotor.

Operation
The axial stage accelerates the air, which is then decelerated through divergent stator vanes, thus increasing the air pressure. The same process is repeated throughout all the compressor axial stages.

The dynamic pressure (air velocity) generated by the centrifugal impeller speed is transformed into static pressure by the gas generator case diffuser pipes (divergent shape) which reduce the air speed and increase the compressor discharge pressure (P3).

The number 1 and 2 bearings support the compressor rotor.

Maintenance
- Check the first stage blades for FOD every time the inlet screen is removed.
- Refer to the Engine Maintenance Manual for acceptable blade damage and blending limits.
- Carry out compressor washes per the Engine Maintenance Manual, Chapter 71-00-00, Cleaning.:
- The Desalination Wash is to remove salt deposits and light dirt deposits from the compressor section. It should be done daily in a continuously salt laden environment and weekly in an occasionally salt laden environment.
- The Performance Recovery Wash is required to remove stubborn dirt from the compressor gas path using chemical cleaning agents followed by 1 or more water rinses. This cleaning should be done only when engine performance loss is noticeable or trend monitoring dictates



COMPRESSOR BLEED VALVE (NOT FOR A-64/65/66/67 MODELS)

Purpose
Prevents compressor stalls at low Ng speed.

Description
- Pressure operated piston sliding on a guide pin
- Piston discharges P2.5 to atmosphere at low Ng speed
- A rolling diaphragm mounted on the valve piston prevents leakage between P2.5 and the P3 chamber.

Operation
Two forces act on the bleed valve piston. Modified P3 air (P3 mod) pressure pushes to close the valve and P2.5 air pressure, from the interstage compressor area, pushes to open it.

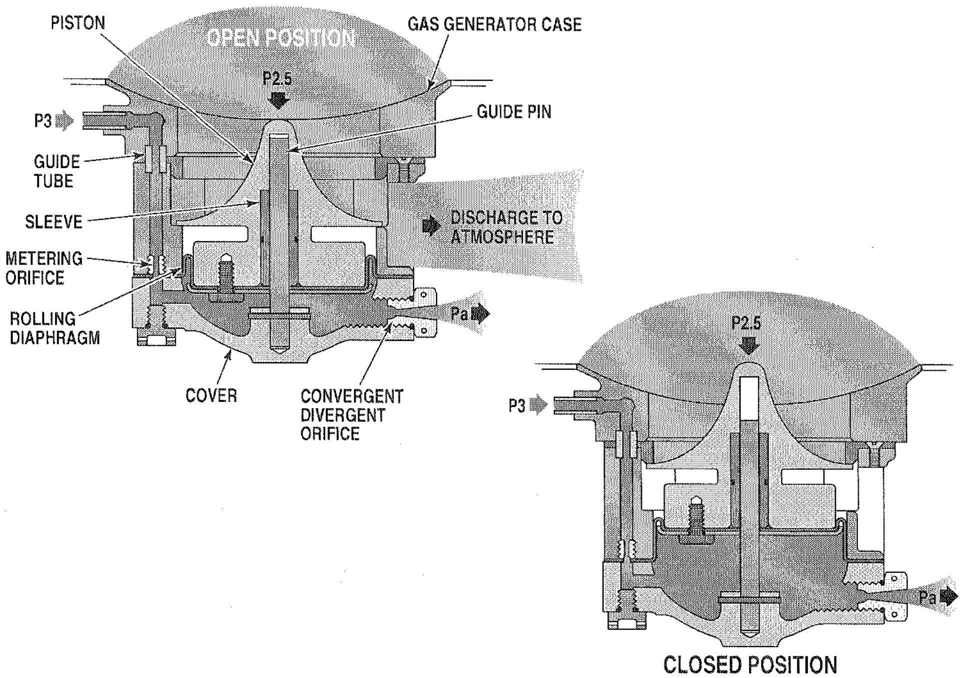
P3 air flow through a primary metering orifice and is directed to the top of the piston and to atmosphere via a convergent divergent orifice. The valve closing point is achieved during engine acceleration when the pressure acting on the valve diaphragm (P3 mod) is sufficient to overcome the compressor interstage pressure (P2.5).

As the compressor speed increases, P3 rises faster than P2.5, thus increasing the pressure acting on the piston to gradually close it. The speed (Ng) at which the valve closes is a function of the primary and convergent divergent orifices sizes. A larger primary orifice requires less Ng speed (less P3 pressure) to close the valve.

Note
- The orifices are matched to the bleed valve and are not field replaceable unless specified in the Engine Maintenance Manual.

Pilot tip:
- Throttle back if continuous compressor surge is encountered.
- Accelerate slowly if an engine is prone to surge.
- Surge may damage the compressor and hot section. Have the engine/bleed valve checked.

TYPICAL SMALL PT6A



Function
Prevents compressor stalls at low Ng speed.

Construction
- Non-flowing type
- A piston slides on a guide pin inside a housing
- Seal rings on the piston minimize Px leak
- A calibrated seat controls the closing point (Ng) of the bleed valve

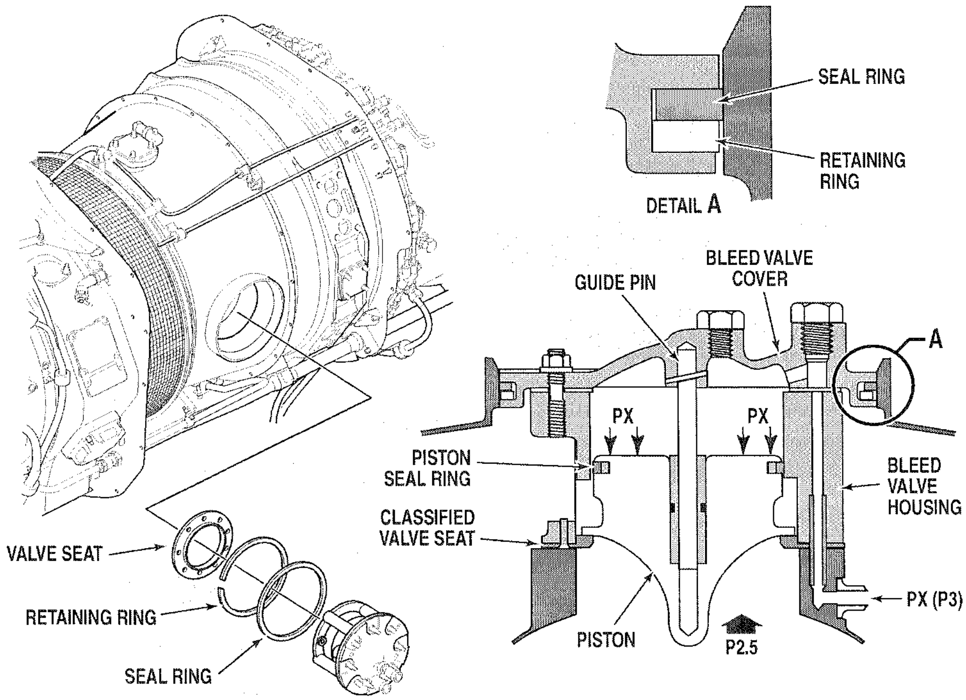
Operation
Two forces act on the bleed valve piston. Px air pressure pushes to close the bleed valve and P2.5 air pressure, from the interstage compressor area, pushes to open it.
Px is derived from P3 air. P3 passes through a restriction when it flows between the no. 2 bearing housing and the no. 2 bearing cover. At low power setting, Px is lower than P2.5 keeping the bleed valve open. In this position, P2.5 air is directed into the plenum chamber and into the inlet case struts. When the compressor speed increases, Px rises faster than P2.5, thus increasing the pressure acting on top of the piston to gradually close it. The speed (Ng) at which the valve closes is a function of 2 variables. One is the Px pressure and the second is the surface area on which P2.5 air pressure is pushing on the piston.

Px pressure depends on the restriction at the outlet of the cavity where it is drawn. This restriction is controlled by the inside diameter of the compressor turbine stator air seal. SB14117 introduces a classified stator air seal on certain engine models to improve control of Px pressure. Some A-65 models (Post SB-13108) also incorporate a classified stator air seal.

The surface area on which P2.5 pushes depends on the Inside diameter of the bleed valve calibrated seat. Different classes of seats are available for bleed valve closing point adjustment.

Note
- Retain classified seat when replacing bleed valve.
- Take care not to drop the piston when the bleed valve seat is removed.

Pilot tip:
- Throttle back if continuous compressor surge is encountered.
- Accelerate slowly if an engine is prone to surge.
- Surge may damage the compressor and hot section. Have the engine/bleed valve checked.



PROBLEM	SYMPTOMS AT CONSTANT POWER			ACTION REQUIRED
	Ng	T5	Wf	
Restricted inlet screen	up	up	up	Clean and/or remove obstruction
Dirty compressor	up	up	up	Perform compressor wash / revise wash schedule
Damaged compressor blades	up	up	up	Return to an authorized overhaul facility if damage is beyond limit
Bleed valve stuck open	up	up	up	Ensure P3 is not leaking between bleed valve and gas generator case. Replace bleed valve.
External P3 air leaks	same or up	up	up	Check for external leaks on gas generator. Verify sealing surfaces at next HSI.
Inertial separator in bypass position	up	up	up	Return separator vanes to normal position.
Bleed valve closing point out of limit	Compressor stalls Possible hooting noise			Replace bleed valve if found defective.
Compressor unbalance	Vibration or humming noise			Inspect first stage compressor blades for FOD

Note: Cold section problems are always characterized by a higher T5 and Wf. Ng usually goes up.

CHAPTER 3
COMBUSTION & TURBINE SECTION

Function
Create and extract energy from the hot expanding gases to drive the compressor turbine, compressor and AGB accessories. At the same time, drive the power turbine(s) and propeller to provide thrust for the aircraft.

Construction
- Annular, reverse flow combustion chamber
- Compressor turbine vane ring assembly
- Compressor turbine and blades assembly
- Power turbine vane ring(s)
- Power turbine(s) and blades assembly
- Power turbine housing
- Exhaust duct

Operation
The hot section of the engine is comprised of the components down stream of the compressor. Hot expanding gases leaving the combustion chamber are directed towards the compressor turbine blades by the compressor turbine vane ring and drive the compressor.

Gases then travel across the 1st stage power turbine vane ring and drive the 1st stage power turbine (and again across the 2nd stage for A-41's and larger engines). Turbine rotation is transmitted to the propeller via the power turbine shaft and the reduction gearbox.

Gases leaving the power turbine(s) are expelled to the atmosphere through the exhaust duct. The exhaust gases add some "jet thrust" as a result of the airframe exhaust stubs.

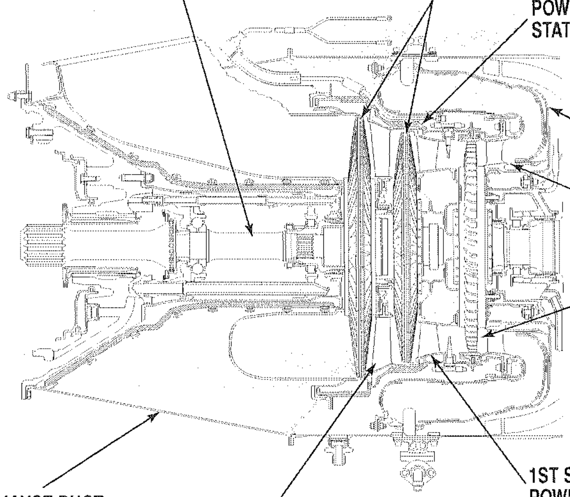
The compressor turbine vane ring is subjected to the highest temperatures within the engine and P3 air traveling inside the vane airfoils provide cooling (no cooling on the A-21/27/28). After cooling, the air is ejected in the gas path.

The compressor turbine and the 1st stage power turbine vane rings are classified and matched at engine test to assure that the Ng and T5 are within specified limits.

Shroud segments, part of the Compressor Turbine Vane Ring Assembly, come in different classes (thickness) to fit different compressor turbine diameters and maintain the gap between the compressor turbine blades and the segments (tip clearance) within specified limits.

Maintenance:
- Carry out the compressor turbine wash per the Engine Maintenance Manual, Chapter 71-00-00, Cleaning.
- The Turbine Wash is to remove salt deposits from the compressor turbine blades. It should be done daily in a continuously salt laden environment and weekly in an occasionally salt laden environment.

Note:
When carrying out compressor and compressor turbine desalination washes, it is essential that the compressor wash be done first.



PROBLEM	SYMPTOMS AT CONSTANT POWER			ACTION REQUIRED
	NG	T5	Wf	
Seal ring leak	same	up	up	Reposition or replace seal ring. Verify seal ring groove and replace shroud housing if necessary.
Gas leakage at junction between small exit duct and vane ring	same	up	up	Lap sealing faces. Replace parts if distorted.
Burnt CT vane ring (larger throat area)	down	up	up	Replace vane ring.
High CT tip clearance	down	up	up	Replace shroud segments to restore clearance. Replace turbine if blades are worn out.
Eroded compressor turbine blades	down	up	up	Send assembly to an authorized facility for blade replacement.

Note: Hot section problems are always characterized by a higher T5 and Wf. Ng usually does down or remains constant.

CHAPTER 4
GEARBOXES

Reduction gearbox

The PT6A engine uses a planetary type reduction gearbox system with two stages of reduction. The first stage consists of a sun gear meshing with three planet gears mounted in a carrier. The three planet gears mesh on the outside with a ring gear into the reduction gearbox casing. The first stage gear carrier drives the second stage sun gear through a flexible coupling arrangement. Provision to measure torque is provided by the first stage reduction system.

The second stage reduction system is similar to the first stage but uses five planet gears instead of three. The second stage carrier is splined onto the propeller shaft.

A bevel gear, on the propeller shaft, provide drives for 3 RGB mounted accessories:

- Propeller Governor / Constant Speed Unit (CSU)
- Propeller Overspeed Governor (Airframe installed except for A-67B)
- Np tacho-generator (except A-67B)

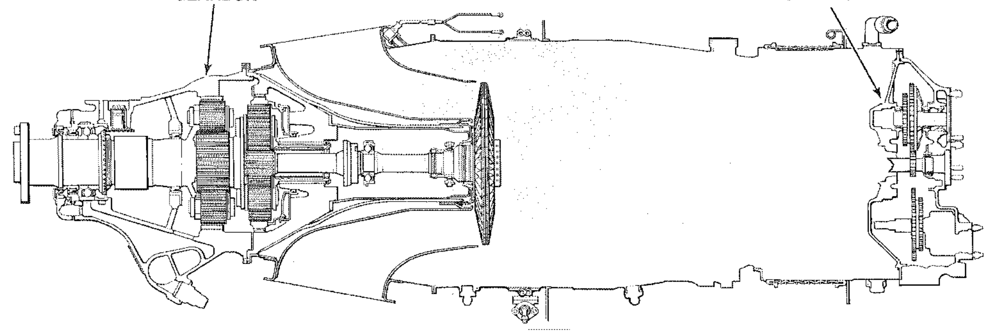
On typical engines, a magnetic chip detector is mounted on the bottom on the RGB to provide an indication of metal particle contamination of the engine oil system.

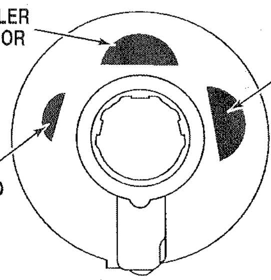
Accessory gearbox

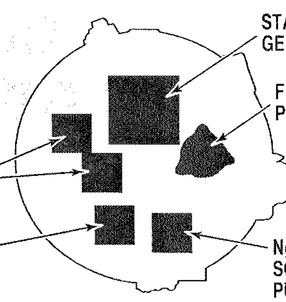
The accessory gearbox is a standard linear reduction located at the rear of the engine and provides rotation for the engine and airframe accessories such as:

- Fuel pump and Fuel Control Unit
- Starter-Generator
- Oil pressure and scavenge pumps
- Ng tacho-generator (except A-67B)
- Optional airframe accessories
- Centrifugal breather impeller to separate the air from the oil in the accessory gearbox. The impeller is mounted on the starter-generator gear.

The accessory gearbox also supports the oil filler neck and dipstick. It also forms the back wall for the oil tank.


REDUCTION
GEARBOX
ACCESSORY
GEARBOX


PROPELLER
GOVERNOR
PROPELLER
OVERSPEED
GOVERNOR
Np TACHO
AS VIEWED FROM FRONT


STARTER
GENERATOR
FUEL
PUMP/FCU
OPTIONAL
ACCESSORY
DRIVE
SCAVENGE
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PUMPS
AS VIEWED FROM REAR

CHAPTER 5
OIL SYSTEM

Description
The PT6A engine oil system consists of a pressure, a scavenge and a breather system. The lubrication system provides a constant supply of clean oil to the engine bearings, reduction gears, accessory drives, torque meter system and propeller governor (for propeller pitch and speed control).

The oil tank is integrated in the engine air inlet casing. The oil lubricates and cools the bearings and carries any extraneous matter to the oil filter where it is precluded from further circulation. A chip detector is located in the reduction gearbox (on some engine models, may also be located on the AGB or under the inlet case) to attract metal particles and warn operators of metal contamination. On some applications, the chip detector is connected to a cockpit warning light.

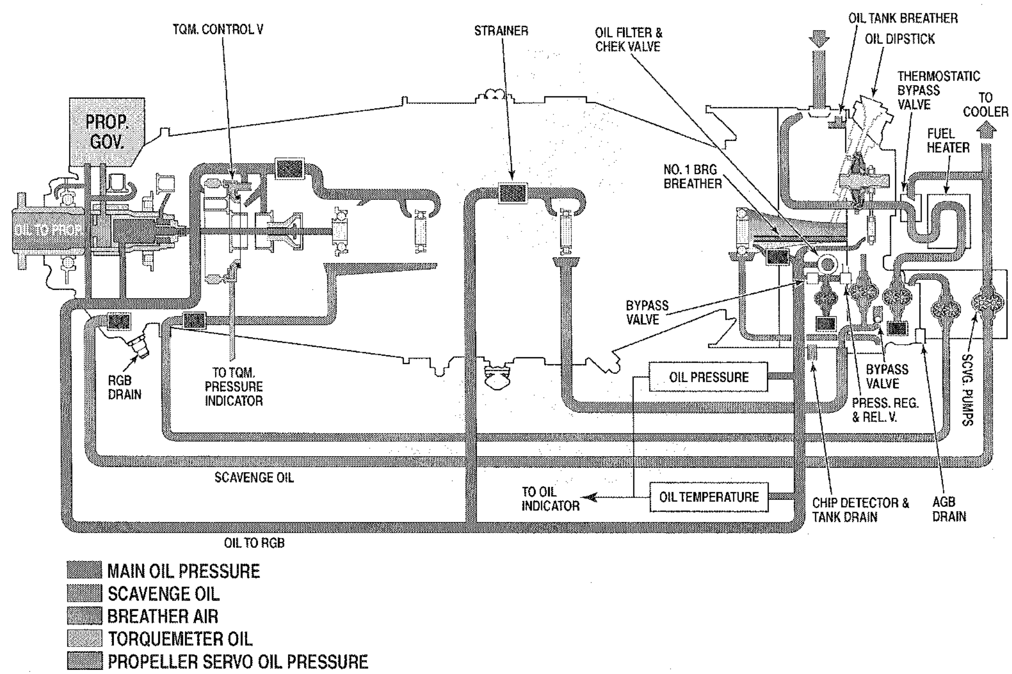
Pilot's tip
- Always feather the propeller prior to shutting down the engine, this will allow the oil from the propeller and RGB area to make it's way back to the oil tank. This will give you more consistent oil levels.
- Operating an engine with the oil pressure below the recommended values may cause severe internal damage. Refer to the POH for the emergency procedures to be followed under low oil pressure conditions.
- After an oil level check, always make sure the locking cap is well secured.

Oil System Servicing
- Use approved synthetic oils listed per the applicable service bulletin.
- No intermixing of different oil brands or viscosities in an engine.
- Check the oil level 15 to 20 minutes after shut down.
- If the engine has been shut down for more than 30 minutes and the dipstick indicates that oil is needed, **run** engine at ground-idle for 5 minutes before rechecking oil level.
- Ensure that the oil pressure is within limits.

Dipstick and oil sight glass:
- Shows the oil quantity needed to keep the tank full, normal cold oil level is 'MAX COLD' or within the green band for the engines equipped with a sight glass.

NOTE:
- Filling the oil to 'MAX COLD' may result in high oil consumption (i.e.: oil exiting the AGB breather). This may also occur with levels at one or two US quarts below 'MAX COLD'. Operators are advised to service the oil to the level that results in acceptable consumption, down to 3 quarts below the maximum, if necessary.

Locking Cap:
- Seals the oil tank when closed by a latch.
- A new style filler neck, with a ball check valve that restricts the oil flow out of the oil tank in case of a wrongly installed locking cap, has been introduced under the following SB's: 1451, 1506, 3378, 12123, 13340 & 14301.


TQM. CONTROL V
STRAINER
OIL FILTER & CHEK VALVE
OIL TANK BREATHER
OIL DIPSTICK
THERMOSTATIC BYPASS VALVE
TO COOLER
FUEL HEATER
PROP. GOV.
OIL TO PROP
NO. 1 BRG BREATHER
BYPASS VALVE
RGB DRAIN
TO TQM. PRESSURE INDICATOR
OIL PRESSURE
BYPASS VALVE
PRESS. REG. & REL. V.
SCVG. PUMPS
SCAVENGE OIL
TO OIL INDICATOR
OIL TEMPERATURE
CHIP DETECTOR & TANK DRAIN
AGB DRAIN
OIL TO RGB
MAIN OIL PRESSURE
SCAVENGE OIL
BREATHER AIR
TORQUEMETER OIL
PROPELLER SERVO OIL PRESSURE

CHAPTER 6
SECONDARY AIR SYSTEM

General

The secondary air system consists of engine airflow used for other means than producing power.

Of all the air entering the compressor, approximately:
- 25% is used in the combustion process
- 65% is used to cool the combustion gasses
- 5% is allowed for airframe services
- 5% remaining is used by the secondary air system.

The Secondary Air System provides air pressure for:
- Cooling of hot section parts
- Sealing of bearing compartments
- Operation of the bleed valve(s)
- Operation of the fuel purge valve (some models)
- Operation of the fuel control unit (FCU)

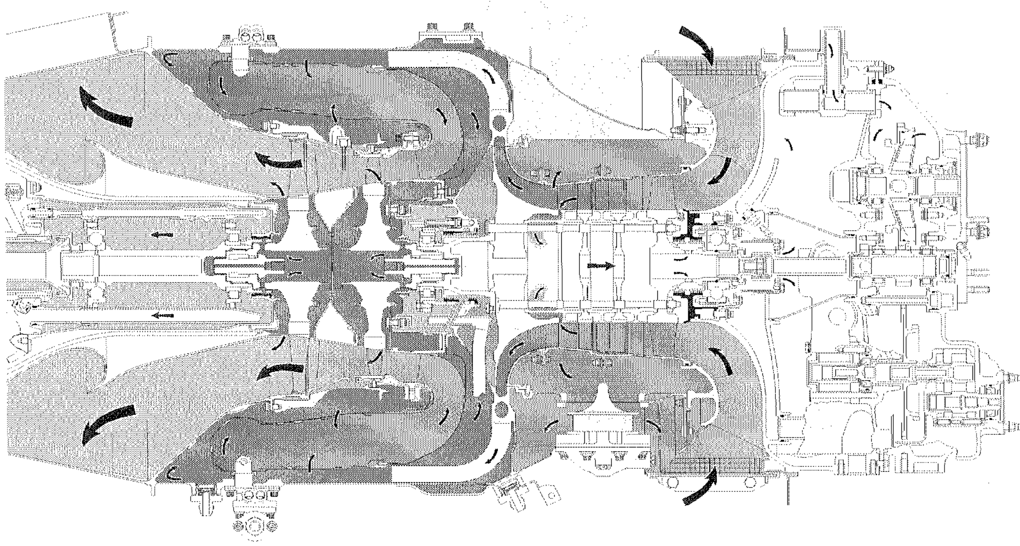
The two sources of air used in the Secondary Air System are:
- **P2.5**, Compressor Inter-stage air pressure
- **P3**, Compressor delivery pressure

Turbine section cooling and airbleed system

Internal passages in the engine distribute P3 air to provide cooling to the combustion chamber turbine and vane rings. After cooling, the air is evacuated in the gas path.

Using the same distribution passages, P2.5 and P3 air are provided to the no. 1, 2 and 3 bearing labyrinth seals. The air flows into the bearing compartments and is evacuated via the oil scavenge system and discharged overboard through the centrifugal breather impeller located in the accessory gearbox.

Tapping on the gas generator case provides P2.5 and/or P3 air for external systems such as cabin environmental control system, de-icing system, door sealing, etc.



CHAPTER 7
ENGINE INDICATING SYSTEM

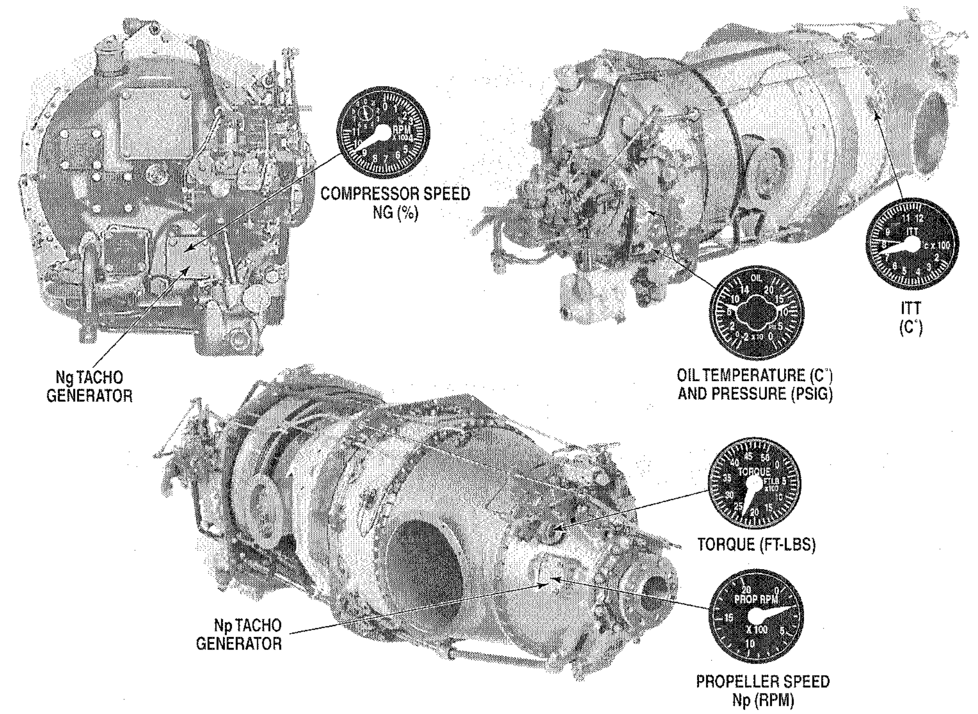
Purpose
- Provide the pilot with indications concerning the engine parameters during flight.
- Provide the required data for ECTM (Engine Condition Trend Monitoring) and performance check on the ground.

Description
Different systems are designed into the engine to transmit signals such as torque, propeller speed, Interturbine temperature, compressor speed, etc. All these signals are sent electrically to the instrument panel in the cockpit.

Typical airframe indication
- Compressor speed
- Oil temp indication
- Oil pressure indication
- Propeller speed
- Torque indication
- Interturbine temperature system (T5 or ITT)
- Chip detector (option)

Indicating systems built into the engine
- Inter-turbine temperature system (T5)
- Torque indication system
- Chip detector

Typical Cockpit Indicators:
- **Yellow**: Transient operating range
- **Green**: Normal operating range
- **Red**: Outside of allowable range



TEMPERATURE INDICATING SYSTEM

Purpose
Provide the pilot with an indication of the engine temperature between the compressor turbine and the first stage power turbine vane ring (station 5).

Description
- 8 or 10 individual thermocouples (chromel-alumel) (number of thermocouple will vary by engine model and also by SB)
- 1 positive bus bar (chromel - small size connector)
- 1 negative bus bar (alumel - large size connector)
- 1 trim probe (maybe be adjustable or fixed class type depending on SB)
- 1 T5 wiring harness

Operation
As temperature increases, an increasing voltage is generated at the chromel/alumel junction of each thermocouple.

Uneven heat distribution within the gas path causes individual thermocouples to see different temperatures and generate different voltages.

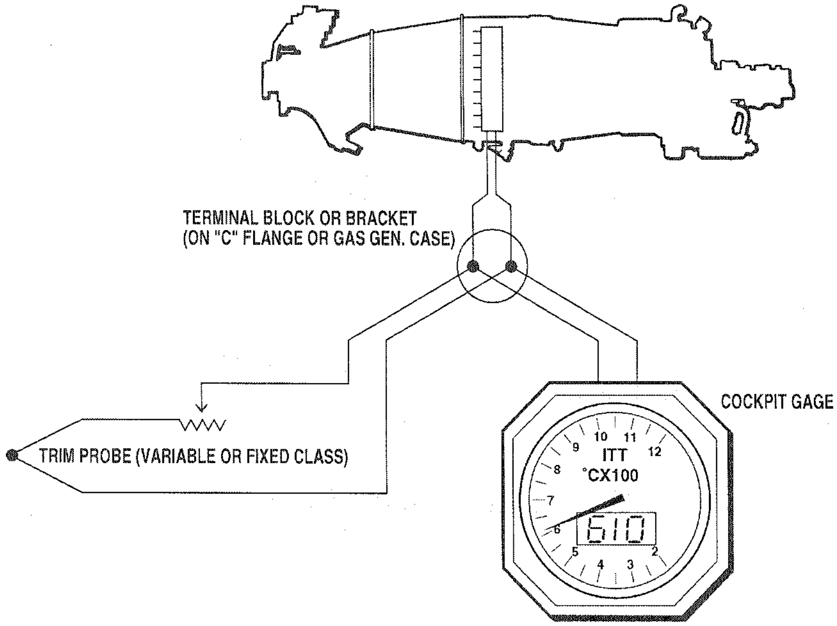
To obtain an average reading, the thermocouples are connected in parallel. Also, a trim probe, located over the inlet case, is connected in parallel with the probes to correct for sampling errors and bias the average temperature. The resultant corrected temperature is read in the cockpit.

Troubleshooting:

Problem Area	Symptom
Burnt Probes	T5 drops due to loss of probes in hot spots (typical)
Short Circuit To Ground	T5 drops due to complete or partial loss of T5 signal
Trim Probe Open Circuit	T5 increases due to loss of trimming function
High Resistance On T5 Circuit Between Engine And Aircraft Gage	T5 drops due to reduction of T5 signal to the cockpit gage
Trim Probe Resistance Drifting	T5 increases if trim resistance increases and vice versa
Split in T5 readings on twin engines	Maybe due to one new & one older engine. Maybe higher on one engine if that engine had a "Hot Start"

Pilot tip:
Operating the engine at, or above, maximum temperature may damage or shorten hot section component life.

Pilot info:
Maximum T5 (ITT) is a limit and not a target.



TORQUE SYSTEM

Purpose
Provide an onboard power reference for the pilot.

Description
The torque system is a hydro-mechanical system comprised of:
- Floating first stage ring gear with helical splines
- Piston
- Cylinder
- Spring loaded oil control valve

Operation
Torque applied to the propeller induces a small rotational and rearward movement of the first stage ring gear. This movement is due to the helical splines on the ring gear. The ring gear pushes the piston and the control valve. Moving the control valve to the rear opens the orifice and allows more oil pressure to push on the piston against the ring gear mechanical force.

The movement of the ring gear for a given torque stops when metered oil pressure in the torque meter chamber exactly balances the rearward force of the ring gear.

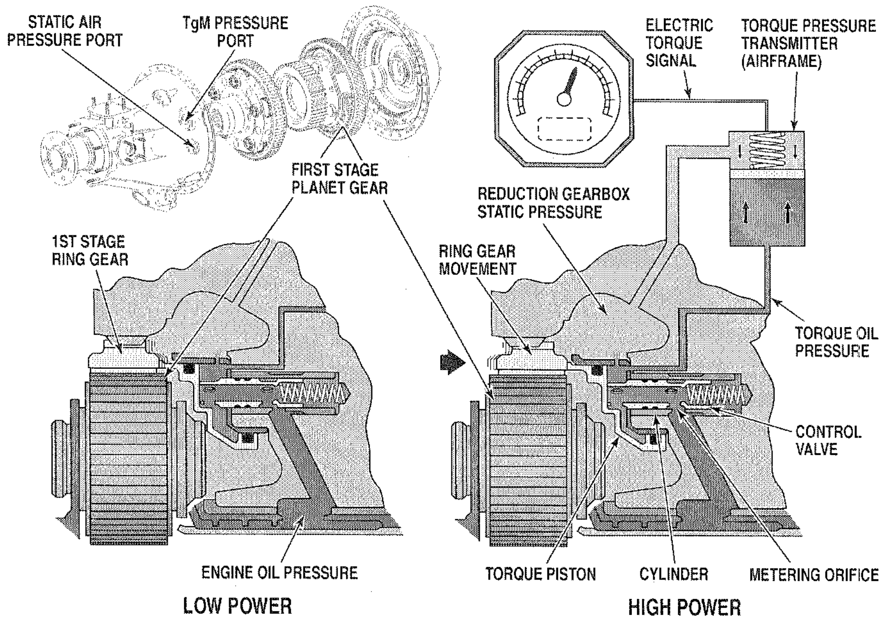
Static air pressure inside the reduction gearbox acts on the torque meter piston and would cause erroneous torque reading. For this reason, static pressure is sent to the transducer and subtracted from the torque reading.

Troubleshooting:

Problem Area	Symptom
Control Valve Stuck Open	Torque goes off scale (high)
Worn Piston Seal Rings	Torque indication low Set oil pressure to the max limit
Defective Transducer/Gage	Torque may indicate high or low
Oil In RGB Static Line	Torque fluctuation

Pilot tip:
- When reporting a problem make sure the relationship between Ng, Np and Tq is noted.

Pilot tip:
- A faulty torque transducer may cause the engine parameters to indicate higher or lower than normal. This is easy to understand, as the pilot sets engine power using torque as reference.


STATIC AIR PRESSURE PORT
TgM PRESSURE PORT
FIRST STAGE PLANET GEAR
1ST STAGE RING GEAR
ENGINE OIL PRESSURE
LOW POWER
ELECTRIC TORQUE SIGNAL
TORQUE PRESSURE TRANSMITTER (AIRFRAME)
REDUCTION GEARBOX STATIC PRESSURE
RING GEAR MOVEMENT
TORQUE OIL PRESSURE
CONTROL VALVE
TORQUE PISTON
CYLINDER
METERING ORIFICE
HIGH POWER

CHAPTER 8
IGNITON SYSTEM

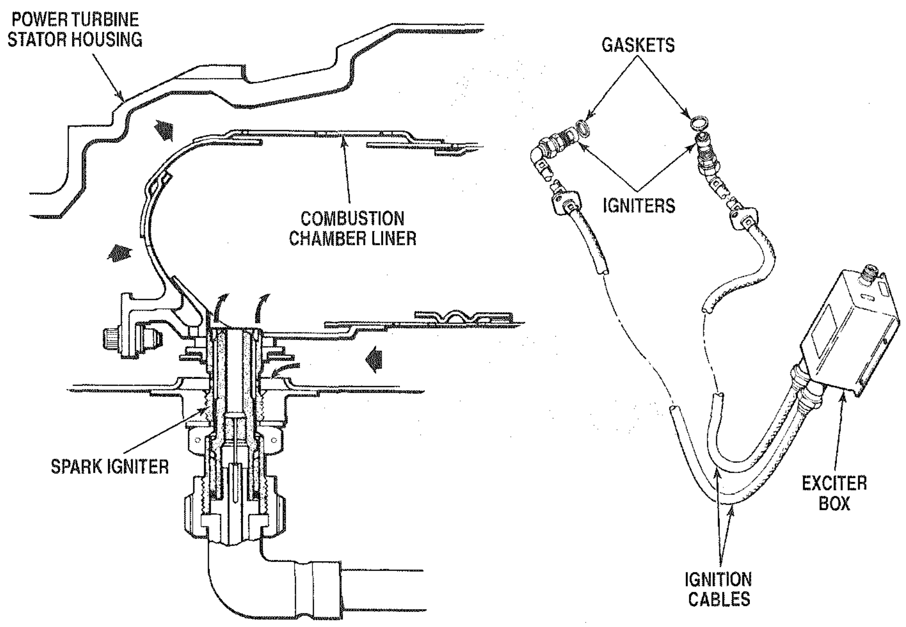
Purpose
Provide the energy source necessary to ignite the fuel/air mixture.

Description
Two ignition system types can be used on the PT6A engines: **glow plug** or **spark igniter**.

- **Glow plug system:**
  The glow plug system consists of a current regulator, two tension leads and two glow plugs.
  This system uses the heat produced at the tip of the glow plug (incandescent) to ignite the air/fuel mixture.
  This type can be found on the A-20 (pre SB1429) as well as on the A-21/27/28/34/36 (pre SB-1196).

- **Spark igniter system**
  The spark igniter system consists of an ignition exciter, two high tension cables and two spark igniters. This system uses a high intensity spark produced at the tip of the spark igniter to ignite the air/fuel mixture.

Pilot tip
- When starting an engine with a **glow plug** system, **wait** an additional **5 seconds** after Ng has passed through, or has stabilized above, the minimum light-off speed, before advancing the Fuel Condition Lever. This will allow the plugs to reach their glowing point.


POWER TURBINE
STATOR HOUSING
COMBUSTION
CHAMBER LINER
SPARK IGNITER
GASKETS
IGNITERS
EXCITER
BOX
IGNITION
CABLES

CHAPTER 9
PERFORMANCE

Purpose
A new PT6A will produce the quoted power with observed ITT, Ng speed and Wf below their respective limits by a certain amount which is called the margin. Margin is built into every new PT6A, periodically an engine can be run and checked against the airframer's performance chart to see what remains of this margin.

The airframe performance curves establishes the engine parameter limits of an acceptable engine for different atmospheric conditions which permits verification of the engine condition over a wide range of ambient temperatures and pressure altitudes without exceeding torque, Ng or T5 limits.

The check is performed at a given power where engine torque pressure (Tq) and propeller speed (Np) are constant and the values obtained for Ng, T5 and Wf are compared to the chart limits.

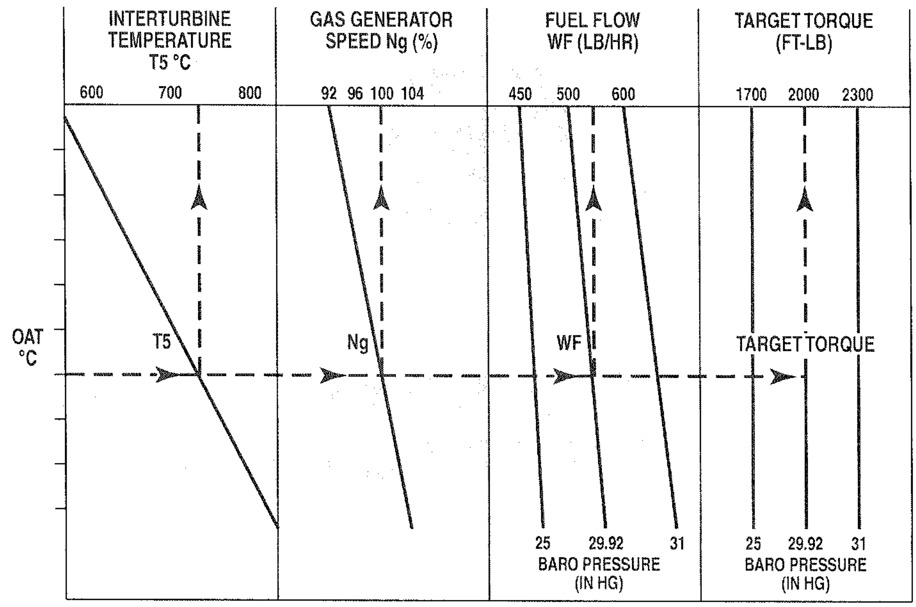
The interval is at operator's discretion.

Pilot tip:
- An engine that exceeds the performance chart limits, but stays under the gage red line, does not mean the engine is good but represent an engine that has eaten away its margin and should be repaired.
- All engine ratings used during flight are dictated by a POH. Operating the engine beyond the required power may not exceed any of the mechanical limits but may accelerate the engine aging process and lead to premature repairs.
- All forms of engine deterioration are accompanied by an increase in T5 and Wf at a given power. Compressor deterioration is, in most cases, due to dirt deposits and causes an increase in Ng at a given power setting. This form of deterioration can be remedied by field cleaning. Hot Section deterioration, in most cases, causes a decrease in Ng at a given power setting.

Deviations from the predicted values in the Aircraft Maintenance Manual are not cause by themselves for engine rejection. Do troubleshooting and additional testing as required.

Also, a single performance parameter outside the expected value usually means a fault in the indicating system. An engine fault is usually indicated by two or more performance parameters outside the expected values.

ENGINE PERFORMANCE CHART (TYPICAL)



Np = 1700 RPM

EXAMPLE:

OAT = 20°C	Ng = 100%
BARO = 29.91 IN HG	WF = 560 LB/HR
ITT = 733°C	TARGET TQ = 2000 FT-LB

ENGINE CONDITION TREND MONITORING

Purpose
ECTM™ is a process which allows the user to monitor the engine performance and will:

- Permit early detection of engine deterioration
- Reduce troubleshooting time by directing the technician to the general area requiring attention on the engine
- Reduce operating and maintenance costs
- Increase dispatch reliability
- Allow for repairs to be performed at the most economical time
- Allow for "**On-Condition Hot Section Inspection**"

Additional information is available under the following:
SIL GEN-010: for the System V information, hardware requirements and price

SIL GEN-011: for the Designated Analysis Centers (DAC)

SIL GEN-055: for general information regarding ECTM™

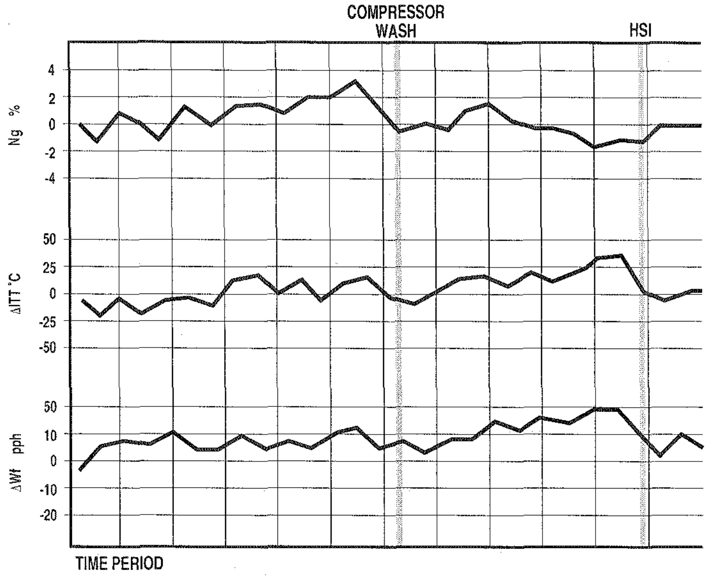
SIL GEN-PT6-021: for Altair Avionics Corporation, which offers the possibility of incorporating an automatic recording system for the aircraft parameters

Description
The **Engine Condition Trend Monitoring** is essentially a three-part process:

1) The following in-flight cockpit data may be gathered by the pilot or by an automatic recorder:
   - Torque
   - Propeller Speed
   - Compressor Speed
   - Inter Turbine Temperature
   - Fuel Flow
   - Indicated Outside Air Temperature
   - Pressure Altitude
   - Indicated Airspeed

2) The data is mathematically converted to standard conditions (sea level) and then compared to a nominal engine (a mathematical model) to produce deltas, which are presented graphically to permit trend analysis. The primary function of this program is to take the data inputs and produce a graphical output. The output can be quickly viewed on the screen or printed for detailed analysis.

3) The last, and equally important part, is the analysis of the trends. This forms the basis for the "**On-Condition HSI**" concept of Hot Section Inspections, as well as for scheduling other maintenance such as compressor washes, instrument calibration and/or replacement.

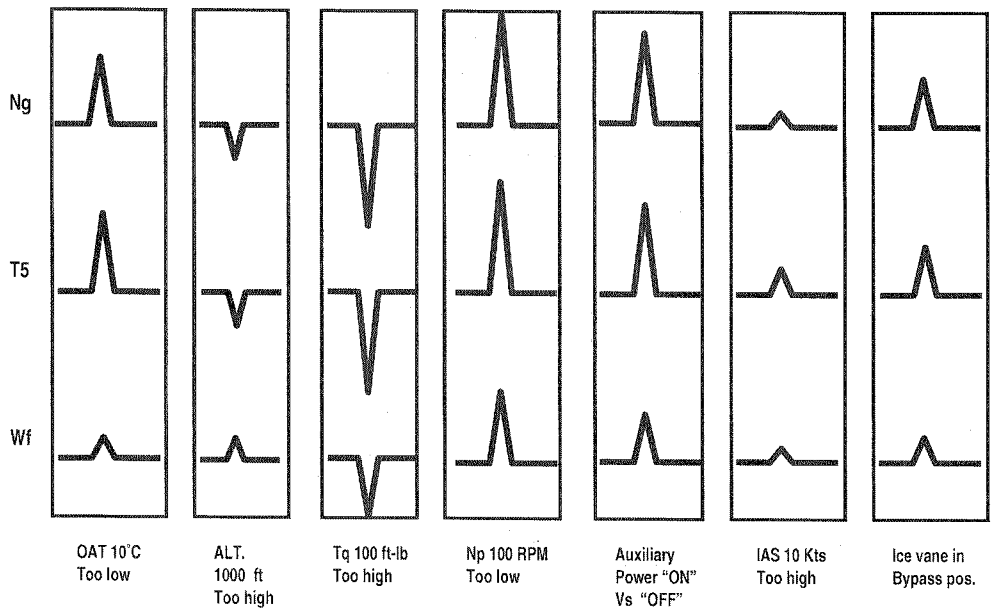


Minimum requirement for valid ECTM™ data
- Record data once a day or every 6 to 8 hours
- Select the flight with the longest cruise portion
- Remain within the same altitude band ± 5000 ft.
- Set power for cruise as per flight manual (POH)
- No throttle or prop speed adjustment for 5 minutes
- Auxiliary power extraction must be repeated
- Set altimeter to 29.92" Hg to get the correct pressure altitude
- If both the Total Air Temperature (TAT) and Static Air Temperature (SAT) are available, use TAT since the ECTM program uses Air Speed for correction
- Analyze data within 3 days

The Precision of recorded parameters is important:
- Targeting Tq and Np
- Record data within 1 minute
- The desired accuracy is to one decimal point when recording Np (or N2) and Ng (or N1), and Tq (PSI, Lbs-ft. or %)
- Don't round the numbers up or down
- It is preferable that the same gages are repeatedly used (i.e. pilot's)
- Avoid parallax error

Sources of error
- Manual recording of ECTM data
- Engine not stabilized (stabilize for 5 minutes minimum with no cockpit lever movement)
- Transient data which causes scatter on the trend graph
- Large errors will shift the delta points up or down depending on the error (see bottom page)
- Interpretation of readings on small analog instruments
- instrument inaccuracy contribute to increase the scatter on the trend graph
- The ECTM program compensates for mismatch in parameters between the two engines as long as accurate parameters are provided

Auxiliary power
- Variable loads extracted from the engine such as: generator/alternator, hydraulic, air conditioning and bleed air affect the total engine output
- Auxiliary power is not measurable
- Variation in the engine load affects the trend accuracy
- The engine load condition must be repeated every time that ECTM parameters are recorded.



Operating limits

- Refer to the Pilot Operating Handbook (POH) or the Airframe Maintenance Manual for limits
- P&WC philosophy requires that the POH power specification, for all ratings, be maintained throughout the life of the engine
- The engine is designed to deliver this performance until normal wear indicates that a Hot Section Inspection (HSI) or complete overhaul is required (i.e.: when the engine can no longer achieve the specified power without exceeding operating limits)

Note

- Except for idle, all power settings are set to torque. T5 and Ng are to be checked for exceedance only.

Take-Off (TO)

Take-Off power allows the aircraft to safely lift and climb at a predetermined rate and should not be associated with maximum power or maximum Ng. It is actually a power setting dictated by the aircraft manufacturer within the engine's rated performance. This setting is found in the POH and should not be deviated from. Take-Off is usually limited to 5 min.

Climb

Climb power is usually set to a torque but in a climb situation a nominal T5 becomes the prevalent factor. As the aircraft rises, the engine is submitted to diminishing amounts of air which lower available power. The pilot may attempt to bring the power up thus making the T5 rise accordingly. At this point, the climb should be targeted to a nominal T5.

Cruise

Different cruise settings can be found in the POH and are set to a target torque. Available settings such as maximum cruise or economy cruise will optimize either for speed or fuel economy or a combination of both.

PARAMETER EXCEEDANCES

- Overtemperature, overtorque and overspeed conditions are cumulative
- Several small excursions above the operating limits are as damaging as 1 larger exceedance
- It is important to report the exceedance immediately
- Record the peak value and duration of the exceedance as accurately as possible
- Following an excursion beyond the operating limits, you must carry out the corresponding inspection requirements as found in the Engine Maintenance Manual (refer to 72-00-00, Inspection, Unscheduled Inspection section for details)

PERFORMANCE RELATED TERMS

Margin

Amount of unadvertised performance, which is used as the engine gets older to maintain the rated power.

Transient / acceleration

A point that you pass through but never dwell at.

Power setting	SHP @ OAT	Torque	Maximum ITT	Ng	NP	Oil Pressure	Oil Temperature
		lb-ft / PSI	°C	RPM / %	RPM / %	PSI	°C
Take-off	1100	3625	820	39,000 / 104	1700 / 100	90 to 135	10 to 110
Maximum continuous	1100	3625	810	39,000 / 104	1700 / 100	90 to 135	10 to 110
Maximum Cruise	1000	3625	800	39,000 / 104	1700 / 100	90 to 135	10 to 105
Normal cruise/ max. climb	1000	3625	750	39,000 / 104	1700 / 100	90 to 135	10 to 105
Min. Idle	-	-	700	21,000	-	60 min.	- 40 to + 110
Starting	-	-	1000 *	-	-	200 max.	- 40 (min.)
Transient		5100 **	870 **	39,000 / 104	1870 / 110 **	40 to 200 **	-40 to 110
Max. Reverse	900	-	760	-	1650 / 97	90 to 135	10 to 105

Time limits
*** = 5 seconds**
**** = 20 seconds**

CHAPTER 10
FUEL SYSTEM

POWER MANAGEMENT (TYPICAL INSTALLATION)

The PT6A engine operation is accomplished with three levers in the cockpit.

1) **Power Lever (PLA or throttle):**
The power lever is used to control the compressor speed and to control the propeller pitch in reverse. The lever is connected to a cam cluster (cambox) located on the accessory gearbox. The cam transmits the power lever movement to the fuel control unit, which modifies the fuel flow to the engine and Ng speed.

   In the forward operation mode, the power lever controls Ng speed only and has no effect on the propeller system (i.e.: beta valve).

   From idle (minimum power position) to the full reverse position, the power lever increases Ng and also moves the beta valve to change the propeller blade angle towards the reverse position. This range of operation is referred to as the ground beta range. Taxiing of the aircraft is accomplished in this range.

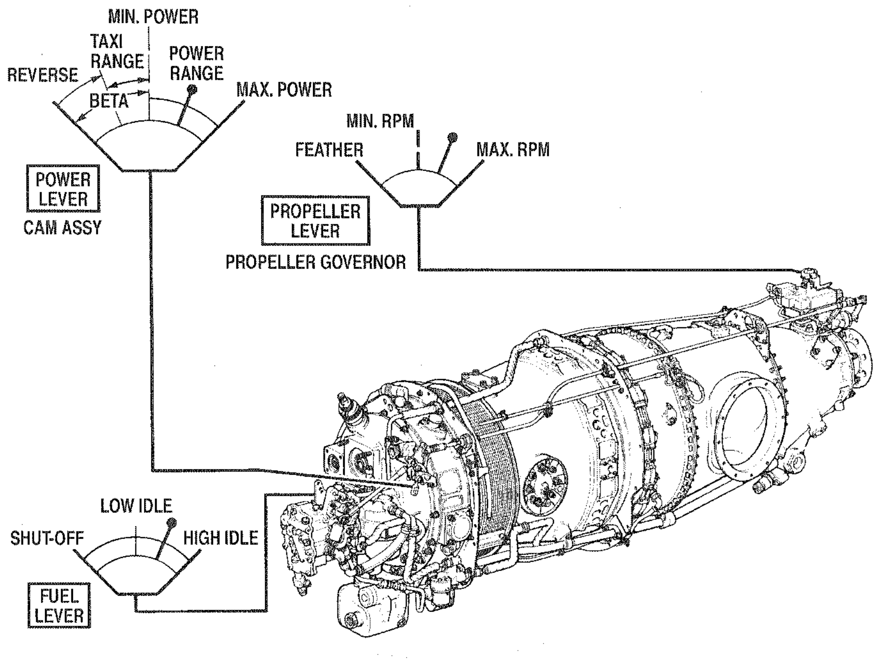
2) **Fuel Lever (Fuel Condition Lever):**
The fuel lever, in the shut-off position, stops fuel flow to the combustion chamber and causes an engine to shut down. At engine start, the low idle position allows the pilot to send fuel to the combustion chamber when the correct Ng speed is reached (12% or 13% minimum depending on the engine model).

   The High-Idle position (optional) is the minimum Ng (compressor speed) allowed for flight operation and is also used for cross generator starts (when applicable).

3) **Propeller Lever:**
The propeller level is connected to the speed lever on the top of the Propeller Governor (Constant Speed Unit or CSU). It is used for two purposes:
   - Controls the propeller speed in the Governing Mode (cruise)
   - Allows the pilot to feather the propeller on the ground prior to engine shut down or during flight, in the event of an engine malfunction.

Notes
- Engines operated with two levers combine the Fuel and the Propeller Speed Lever functions.

- Single engine aircraft may also have a Manual Override Lever (may be called the MOL, Emergency Lever, etc.) which is to be used only in the event of a loss of FCU pneumatic pressure. The override lever provides manual control of the Fuel Control Unit's fuel metering valve. Due to the sensitivity of the lever, operate it slowly to prevent engine surge, overtemperature, overspeed or overtorque conditions.



Purpose
Provides the engine with clean fuel at the required pressure and flow to permit control of engine power.

The fuel system components control the following features:
- Proper fuel flow at minimum fuel introduction speed
- Sequencing fuel distribution to the proper nozzles during start
- Controlling a ground idle speed
- Providing a strong surge free acceleration
- Limiting a maximum compressor speed (Ng)
- Providing a rapid deceleration without extinguishing the combustion
- Providing for fuel shut-off and dump after shut down

Components
- Fuel heater
- Fuel pump
- Fuel control unit
- Flow divider or start flow control
- Dual manifold adapters
- Fuel nozzles (simplex or duplex)
- Fuel drain valves
- Fuel control manual override lever (certain models)
- Fuel control power recovery system (certain models)
- Overtorque limiter or torque controller (certain models)

Fuel and additives
Refer to the Service Bulletin of your specific engine model for the complete listing of **approved, restricted and emergency fuels** as well as additives (for example: anti-corrosion, anti-icing, anti-microbial, etc.).

Note:
Use of Aviation Gasoline (AVGAS) is limited to 150 hour per engine between overhaul periods (TBO).

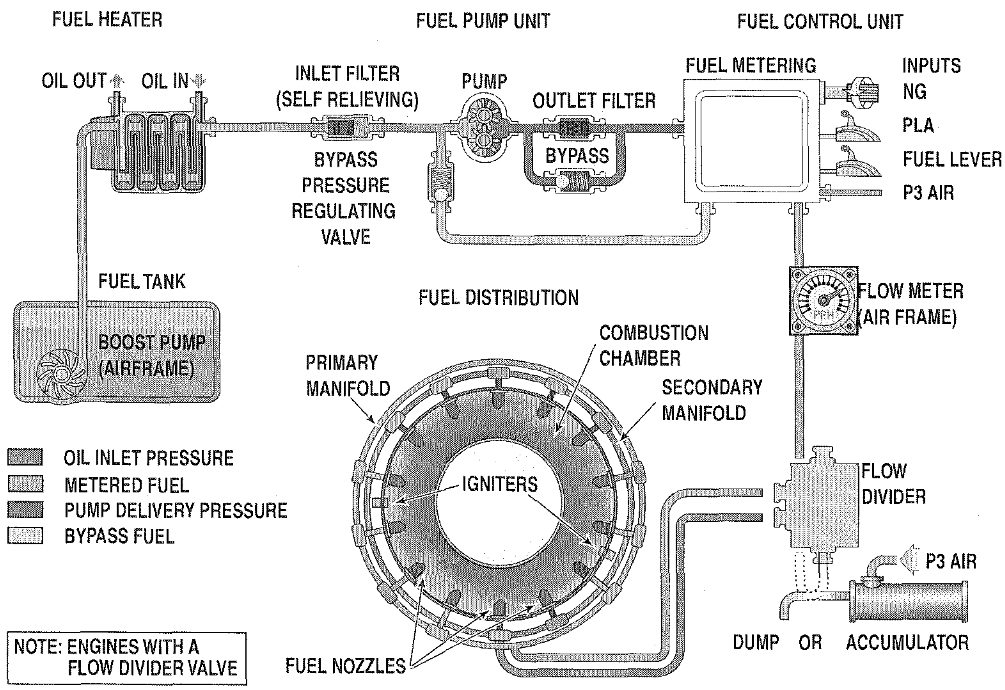
Description
Fuel from the aircraft tanks is sent to the fuel heater via one or more airframe boost pumps. From the fuel heater, fuel is directed to the fuel pump.

The fuel pump sends high pressure fuel to the fuel control unit, which will determine the correct fuel schedule for the required power and ambient conditions depending on the Power Lever position (PLA), the engine Ng and P3 signals.

The fuel is then directed to the flow divider (or start flow control) which will separate the starting flow from the normal running flow before it is delivered to the fuel manifolds and then to the fuel nozzles. The fuel nozzles will atomize the fuel inside the combustion liner.

The fuel drain valves, located under the gas generator case, are used to drain residual fluids.

Pilot tip:
After engine shut-down, verify for the proper operation of the Fuel Heater for excessive operating temperatures. Refer to the Engine Maintenance Manual (71-00-00, Post-Shutdown checks) for details.



FUEL CONTROL UNIT MANUAL OVERRIDE

Purpose
The manual override feature is found on most single engine PT6A powered aircraft and is part of the Fuel Control Unit (FCU). It allows the pilot to directly control the FCU pneumatic section in the event of a loss of FCU pneumatic pressure (P3 or Py).

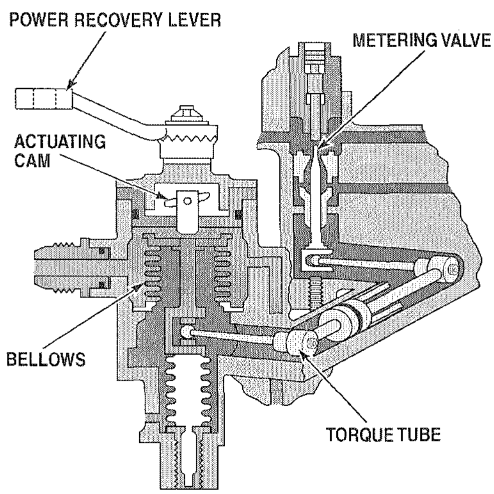
Description
In the event of a P3/ Py air loss or a FCU pneumatic section malfunction, the pilot can manually control the bellows to simulate the FCU working air pressure (P3/Px) and control engine power. A special lever is provided in the cockpit to that effect.

Operation
Movement of the manual override lever in the cockpit will rotate the manual override control lever on the FCU. This lever will act on the FCU's bellows section. The rate of acceleration is established by the speed at which the pilot moves the lever. Any abrupt setting change can cause compressor stalls or create an overspeed, overtorque or overtemperature condition on the engine.

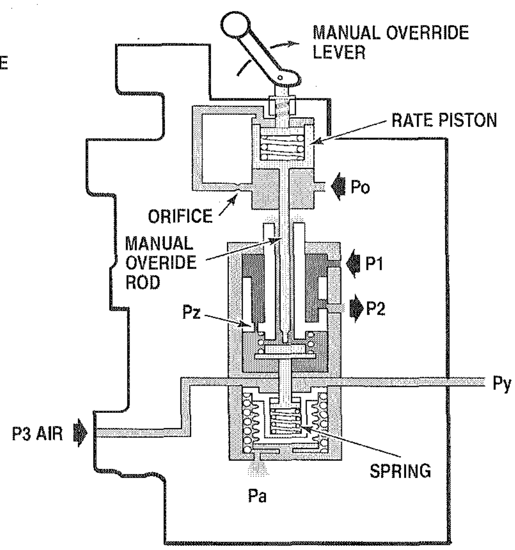
Pilot tip
- **Some** movement of the Manual Override Control lever resulting in **no** increase in engine power is normal.
- The function test schedule and instructions may be part of the Airframe Maintenance Manual, the POH or the P&WC Engine Maintenance Manual.

Function Test (typical)
Following an FCU or engine change or as part of an annual airframe zone inspection (refer to the Aircraft Maintenance Manual), check the serviceability of the manual override system as follows:

1. Carry out the static check with the engine shutdown per the Engine Maintenance manual
2. Set the Manual Override Control lever to the OFF position.
3. Start the engine.
4. Allow the engine to warm up to operating temperature.
5. Keep the **Fuel Condition** lever at GROUND-IDLE position.
6. Keep the **Power Control** lever at GROUND-IDLE position.
7. **Slowly** advance the **Manual Override Control** lever while observing ITT, torque and Ng at all times. Keep Ng maximum increase under 4% per second.
8. **Slowly** increase Ng until a 15% increase above ground-idle speed is obtained. **This indicates proper functioning of the Manual Override System.**
9. **Slowly** reduce the Manual Override Control lever to OFF position, keeping Ng decrease under 4% Ng per second.



BENDIX



WOODWARD

OVERTORQUE LIMITER-CONTROLLER

Function:
A back-up unit which prevents against excessive engine overtorque conditions during transient operation.

Description:
A sealed bellows which senses the torquemeter oil pressure and is linked to a Py bleed orifice.

It can found on the following engine models: A-41/42/42A/64/66A/67AF(post SB 14056)/A-67B(post SB 14154).

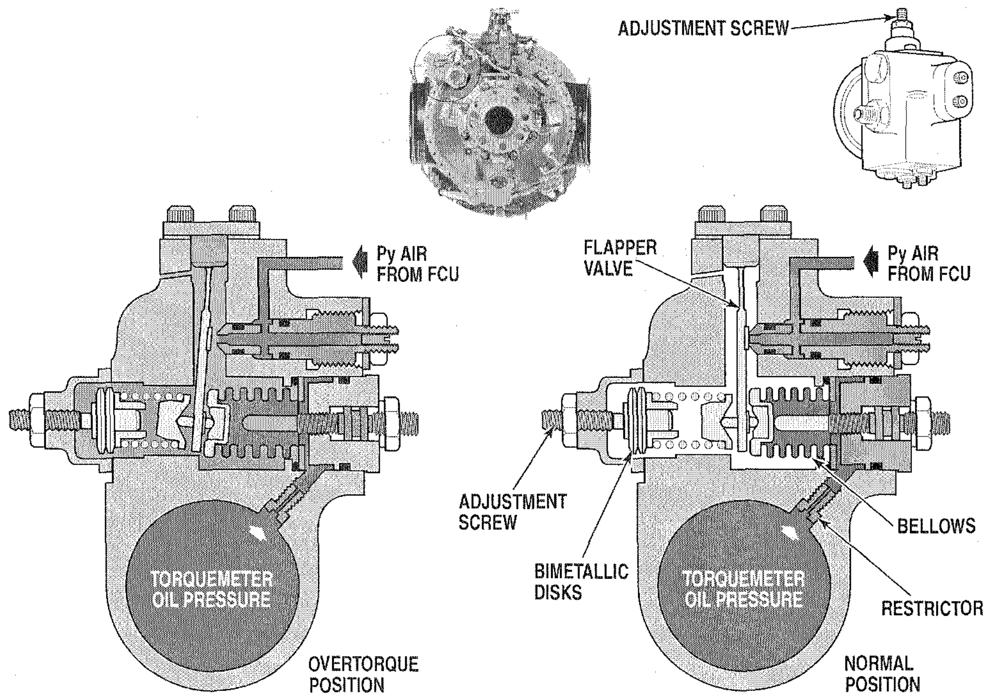
Operation:
Oil from the torquemeter chamber passes through a restrictor before entering the bellows. The restrictor dampens torque pressure fluctuation and prevents damage to the bellows assembly.

If the engine torque pressure reaches a specified limit above the maximum permitted torque, the bellows expands and compresses the spring. The flapper valve will then move to allow Py air pressure from the fuel control unit to bleed to atmosphere and therefore limit the fuel supply to the engine.

Bimetallic disks are mounted on the spring to compensate for variations of spring tension caused by changes in the ambient temperature.

Note:
On some models, a solenoid valve may used to disable the torque limiter function when the unit is not required. The solenoid valve closes when it becomes de-powered to prevent Py air from reaching the torque limiter or controller unit.

Pilot tip:
- The pilot is **always** responsible for operating the engine within limits even if the engine is equipped with an overtorque limiter or controller unit.
- The adjustment value for these units is usually slightly higher than the Take-Off or Climb torque values stated in the POH or the Engine Maintenance Manual operating limits.


ADJUSTMENT SCREW
Py AIR FROM FCU
FLAPPER VALVE
Py AIR FROM FCU
ADJUSTMENT SCREW
BELLOWS
BIMETALLIC DISKS
TORQUEMETER OIL PRESSURE
TORQUEMETER OIL PRESSURE
RESTRICTOR
OVERTORQUE POSITION
NORMAL POSITION

CHAPTER 11
PROPELLER SYSTEM

Purpose
Change the power produced by the engine into thrust in order to propel the aircraft through the air.

Description
The propellers used on PT6A engines vary from one airframe model to the next, will have from three to six blades and be made of metal or composite materials.

They are of the variable pitch, single acting type. A Propeller Governor (Constant Speed Unit or CSU), mounted on the reduction gearbox, adjusts the amount of oil going to the propeller hub which will vary the blade angle to maintain the propeller speed as selected by the pilot.

When more power is applied, the angle of attack of the blade is increased automatically to allow the propeller to absorb the additional energy without an increase in the propeller speed.

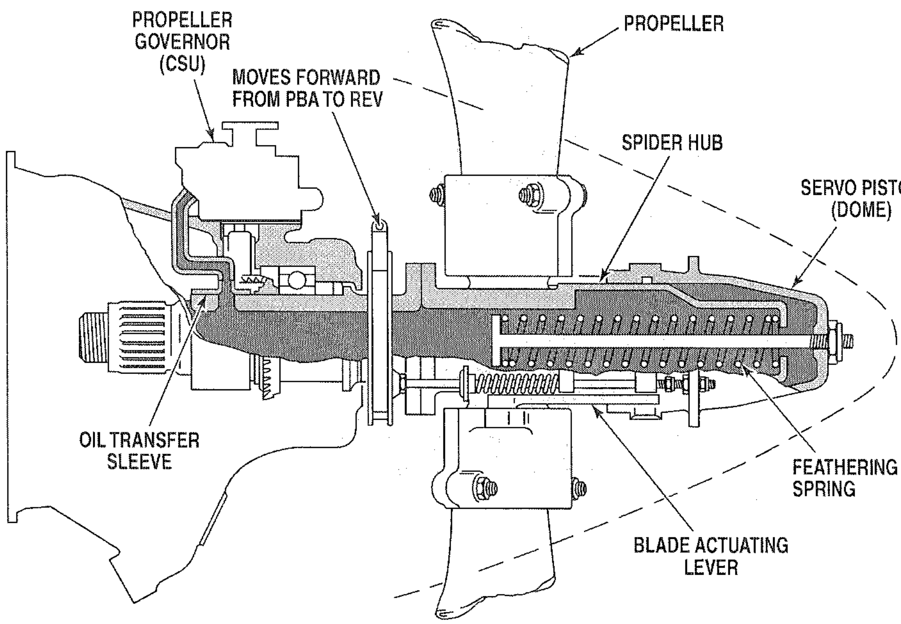
Operation
Oil pressure from the propeller governor flows through the propeller shaft sleeve into the propeller shaft and then to the propeller servo piston.

As the propeller hub oil pressure increases, the servo piston is pushed forward and the feather spring is compressed. The servo piston movement is transmitted to the propeller blade collars via a system of levers which bring the blades towards a finer pitch position.

When the propeller oil pressure is decreased, the propeller feathering spring and blade counterweights force the oil out of the servo piston and change the blade pitch towards a coarser position.

Pilot's Tip

- PT6A propellers are all single acting type meaning you need oil pressure to get the propeller out of feather, no oil pressure and the propeller stays in feather. Low oil pressure will mean more time to get the propeller out of the feather position (towards finer pitch) if at all!
- When doing the Propeller Overspeed Governor check, make sure power levels are maintained low to avoid an overtorque of the engine
- When reporting snags on propeller system make sure of all other parameter movements (Ng, ITT, Wf, Np and Tq).
- The oscillating 'Beta light' (if fitted), when testing the low pitch stop, means the propeller is trying to go below the Primary Blade Angle position (PBA, Low Pitch stop, Flight Fine, etc.) towards the reverse pitch position but the low pitch system is successfully preventing it from doing so!



PROPELLER GOVERNOR (TYPICAL)

Purpose
Controls the amount of oil going to the propeller to allow for propeller speed control and feathering.

Description
It contains a gear type oil pump, a pressure relief valve to regulate the pressure to the propeller. It also contains a speed input section fitted with governor flyweights which react against a speeder spring. Movement of the flyweights will move the pilot valve to control the amount of oil going to the propeller to adjust the blade angle.

Modes of Operation
The Propeller Governor has four modes of operation:

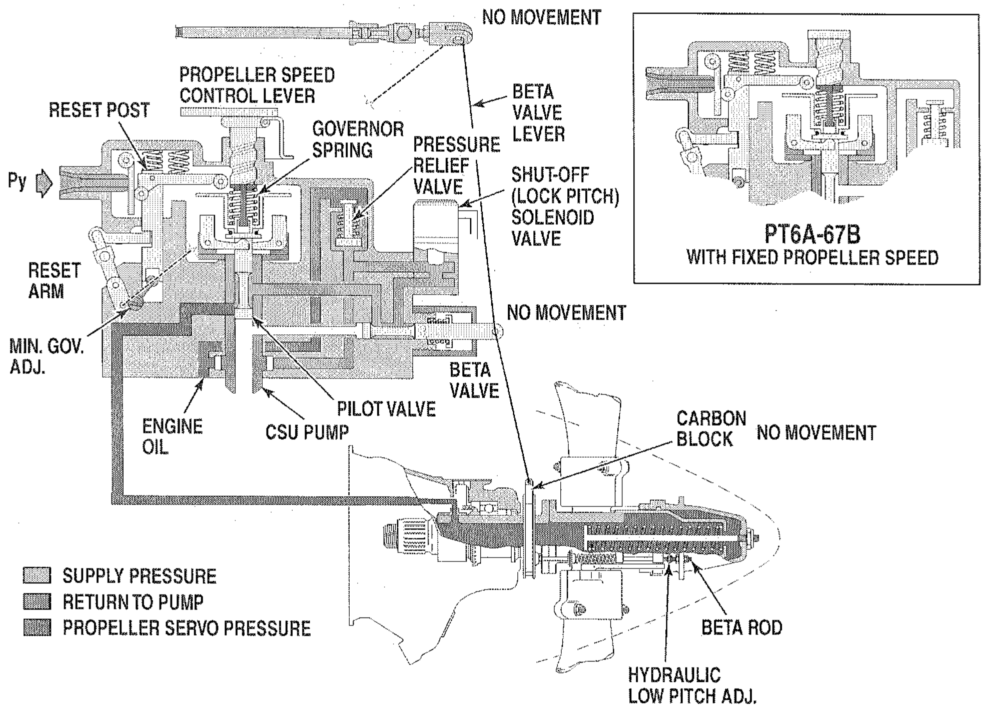
1. **Governing Mode**: range of operation where the engine power is sufficient to maintain the propeller speed selected by the pilot by varying the blade angle. This range of operation is typically between 75% and 100% Np and is controlled by the Power Lever.

2. **Beta Mode (forward)**: range engine of operation where the blade angle is at the Primary Blade Angle position (PBA, Low Pitch stop, Flight Fine, etc.). The propeller pitch stop position is a direct function of the beta valve position. This range of operation is used on the ground or for low power flight with the PLA at the Idle stop gate position.

3. **Beta Mode (reverse)**: the range of operation where the blade angle is between the Primary Blade Angle position and reverse. The propeller pitch is a direct function of the 'Beta' valve position. This range of operation is used on the ground with the PLA below the Idle stop gate position (reverse section on the cockpit Power Lever quadrant). It also limits the engine power in reverse by bleeding air from the FCU pneumatic section.

4) **Feathering**: propeller feathering is achieved by retarding the Propeller Speed Lever to the feather position. This will allow to dump the oil from the propeller back into the reduction gearbox.

PILOT WARNING:
- Do not move the Cockpit Power Lever into the propeller reverse position (i.e.: below the Idle gate or detent) when the engine is stopped. This is to prevent damage to the propeller reverse linkage. Reverse may only be selected with the engine running and the propeller turning.



Purpose
To provide for protection against propeller and power turbine(s) overspeed. There are two systems on the reduction gearbox:

- **Nf Governor** (pneumatic, part of Propeller Governor).
- **Propeller Overspeed Governor** (hydraulic, Airframe).

Nf GOVERNOR
Purpose
In forward propeller operation, will provide a back up to the Propeller Overspeed Governor (A/F). It will limit Np to **approximately 6% above selected propeller speed**.

In reverse propeller operation, will limit propeller speed (reverse thrust) by bleeding Py from the FCU, thus limiting engine power. It will control Np to approximately **5% below selected propeller speed.**

Description
The Nf governor section consists of a Py bleed, a reset post, a reset arm and a reset lever activated by the speeder spring cup.

In the event of a propeller overspeed not controlled by the governor, the flyweights in the CSU will move outwards until the speeder spring cup contacts the reset lever.

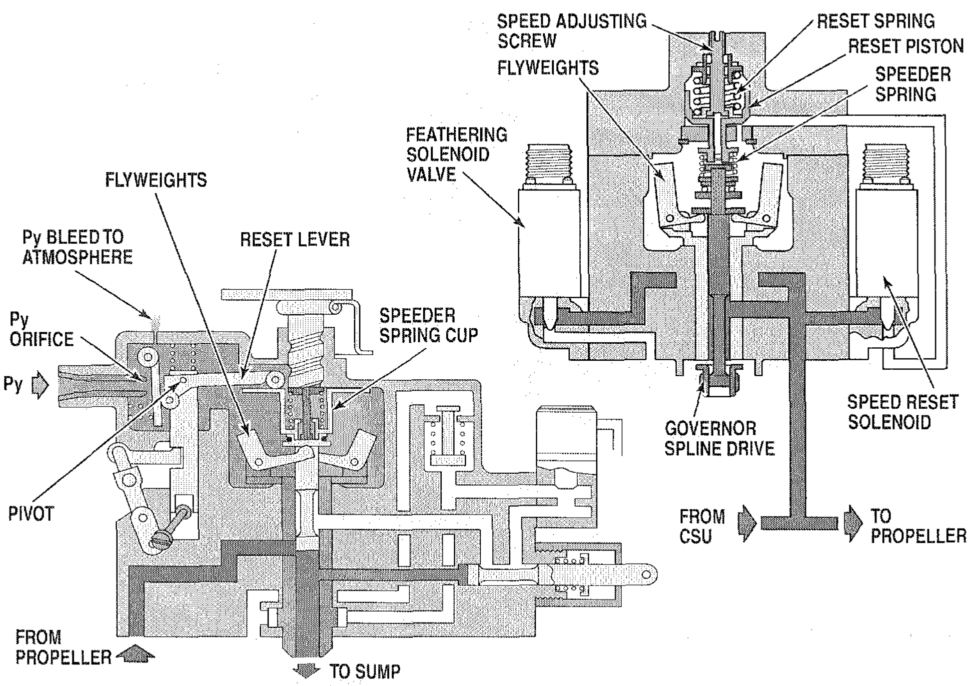
The movement of the reset lever around its pivot opens the Py air passage to bleed into the reduction gearbox. This reduces the fuel supply to the engine, thus the propeller speed.

PROPELLER OVERSPEED GOVERNOR (typical)
Purpose
Provides back up protection against propeller and power turbine overspeed. This is an airframe provided option (except on the PT6A-67B model). It will limit Np to **approximately 4% above the maximum propeller speed.**

Description
The governor houses a set of flyweight connected to a speed input section. The flyweight's centrifugal force is acting against two springs, a speeder spring and a reset spring.

When the propeller speed reaches a specified limit above the maximum Np, the governor flyweights lift the control valve and bleed off propeller servo oil into the reduction gearbox sump, causing the blade angle to increase. An increase in blade pitch puts more load on the engine and slows down the propeller.

To test the unit, a speed reset solenoid is energized and servo oil pressure pushes against the reset piston to cancel the effect of the reset spring. With less spring tension acting on the flyweights, the overspeed governor can be tested at speeds lower than maximum.


SPEED ADJUSTING SCREW
FLYWEIGHTS
RESET SPRING
RESET PISTON
SPEEDER SPRING
FEATHERING SOLENOID VALVE
FLYWEIGHTS
Py BLEED TO ATMOSPHERE
RESET LEVER
Py ORIFICE
SPEEDER SPRING CUP
Py
PIVOT
GOVERNOR SPLINE DRIVE
SPEED RESET SOLENOID
FROM CSU
TO PROPELLER
FROM PROPELLER
TO SUMP

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CHAPTER 12
ENGINE OPERATION

This section will deal with the control of a typical twin-engine aircraft powered by PT6A engines. The following examples illustrate different nominal quadrant positions and the expected engine response, while concentrating in the areas where misunderstandings and occasional confusion exist.

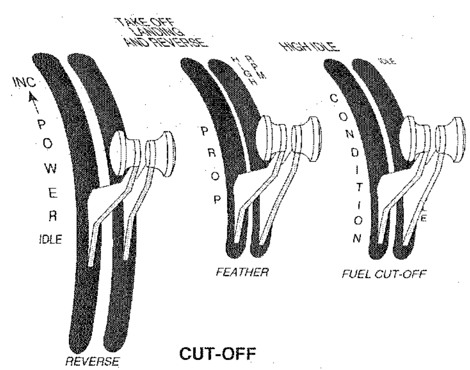
Note:

- Refer to your airframe maintenance manual or the POH for specific operating procedure

Cut-off and pre-start position

In the cut off and pre-start position, fuel is prevented from flowing out the fuel control and the engine cannot be started. Cut off also causes a running engine to shut down.

Prior to starting your engines, carry out the pre-start checks per the POH.



CUT-OFF

WARNING:

- Do not move the Cockpit Power Lever into the propeller reverse position (i.e.: below the Idle gate) when the engine is stopped. This is to prevent damage to the propeller reverse linkage. Reverse may only be selected with the engine running and the propeller turning.

CONDITION LEVER

Advancing the Condition Lever from cut off to Low-Idle position will allow the engine to receive fuel and start. It also allows the fuel control to govern the engine speed at a preset idle value.

STARTING (TYPICAL)

The recommended start procedure is:

1. Engine Starter Switch - ON.
2. Engine Oil Pressure – Check for indication.
3. Ignition Switch – ON.

Note: The minimum Ng to obtain a satisfactory light is 12% (4495 rpm) or 13% (4870 rpm) (dependant on engine model).

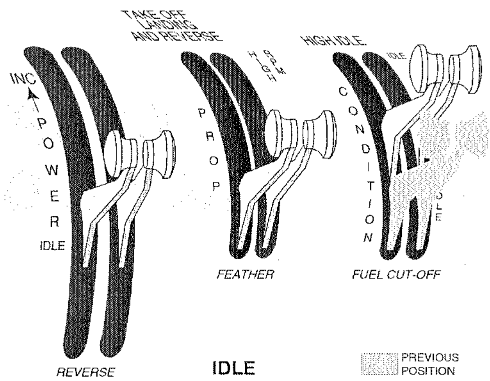
4. As the gas generator speed passes through, or has stabilized above the minimum light-off speed, move the fuel Condition Lever to the GROUND-IDLE (Low-Idle) position.
5. Ensure that the engine accelerates normally to the Low-Idle rpm and that the maximum allowable inter-turbine temperature limit for starting is not exceeded.
6. Engine Starter Switch and Ignition Switch - OFF.

CAUTION:

On multi-engine aircraft, to prevent over-temperature during cross generator starts, make sure the fuel Condition Lever is advanced to Flight-Idle (High-Idle) on the engine supplying generator voltage.

WARNING:

Whenever the gas generator fails to light up within 10 seconds after moving the Fuel Condition Lever to the Low-Idle position, shut off the fuel, starter and ignition. Allow for a 30 second fuel draining period followed by a 15 second dry motoring run before attempting another start. If for any reason, a starting attempt is discontinued, allow the engine to come to a complete stop and then accomplish a dry motoring run. Repeat the complete starting sequence, observing the starter limits (Refer to the applicable Starter Manufacturer's Manual).

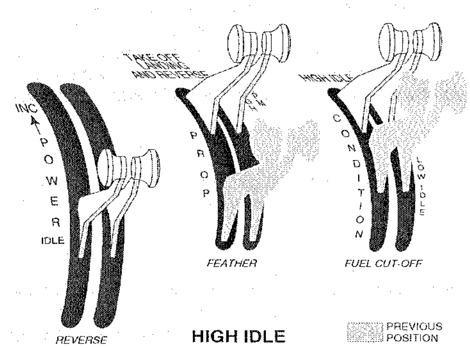


IDLE

PROPELLER UNFEATHERING

Moving the Propeller Speed Lever out of the feather range, towards the HIGH RPM position, will allow the propeller to go towards its low power blade angle position.

Some installations will not have a Propeller Speed Lever. The propeller unfeathering may be accomplished by a solenoid valve mounted on the propeller overspeed governor that will be activated by a micro-switch installed in the Condition Lever quadrant in the cockpit.



HIGH IDLE

HIGH-IDLE

The High-Idle position sets the minimum flight power and is obtained by advancing the Condition Lever to its most forward position. This will move the FCU input arm a predetermined distance to achieve the required compressor rpm (Ng) and engine power.

Pilot tip:

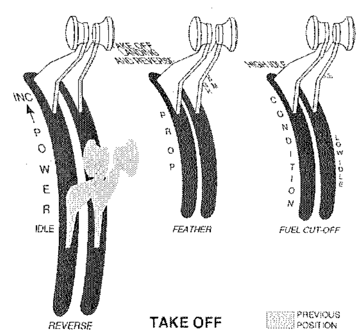
- The Condition Lever should not be retarded lower than this position while the aircraft is airborne.

TAKE-OFF

Moving the Power Lever (PLA) forward will allow you to increase the engine power until the applicable torque is achieved. Take-Off power allows the aircraft to safely lift and climb at a predetermined rate and is actually a power setting dictated by the aircraft manufacturer within the engines rated performance. Take-Off power should not be associated with maximum power or maximum Ng. This setting is found in the pilot operating handbook (POH) and should not be deviated from.

Note:

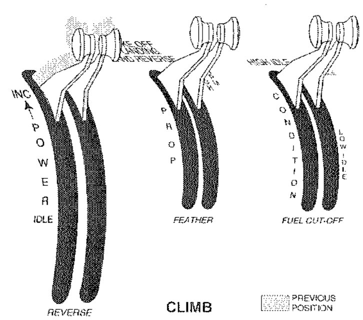
- Take-Off is usually limited to 5 minutes.



CLIMB

Climb power is usually set to a torque value by moving the Power Lever but, in a climb situation, a nominal T5 becomes the prevalent factor.

As the aircraft rises, the engine is submitted to diminishing amounts of air, which lowers the available power. The pilot may attempt to bring the power up thus making the T5 rise accordingly. At this point, the climb should be targeted to a nominal T5.



CRUISE

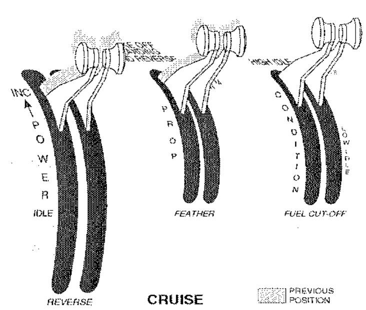
Different cruise settings can be found in the pilot operating handbook (POH) and are set to a target torque. Available settings such as maximum cruise or economy cruise optimize either for speed or fuel economy or a combination of both.

These settings may be achieved by moving the Power Lever to the required power.

To reduce the noise level, the propeller may be set to a lower value by pulling back on the Propeller Speed Lever.

Note:

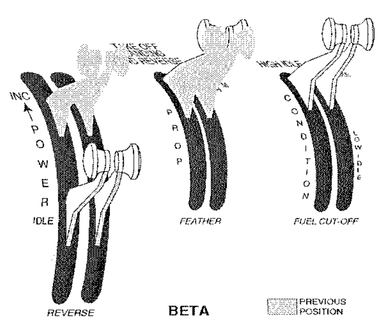
- Except for Idle, the power settings are set to torque. T5 and Ng are to be checked for exceedance only.



APPROACH

The approach setting will typically be achieved by moving the Propeller Speed Lever to the maximum speed position (in case of a "go-around situation") and the Power Lever to the Idle Gate.

In this position, the propeller will go to the Low Pitch Stop position (BETA forward mode) and will be hydraulically locked in this position.

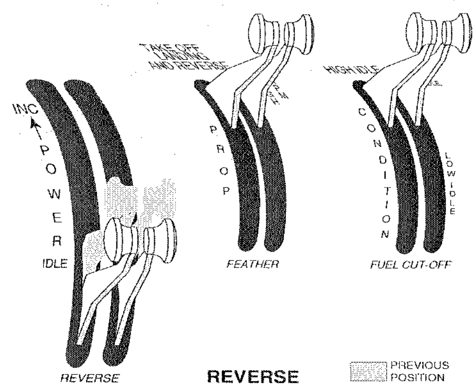


Moving the Power Lever below the Idle gate will allow to manually control the Propeller Governor BETA valve to push the propeller towards reverse pitch. As the lever is pulled back towards maximum reverse, the engine will start to produce reverse thrust. This will create a braking action effect.

Note:
The reverse power settings are in the POH and may be limited to a certain Ng speed, a torque value or a combination of both.

On some airframes, reverse power in flight is prevented from being used by a micro-switch mounted on the landing gear. Upon landing, the micro is de-energized.

WARNING:
Prolonged engine operation in reverse may promote Foreign Object Damage (FOD) to the propeller and compressor.



PROPELLER FEATHERING AND ENGINE SHUTDOWN

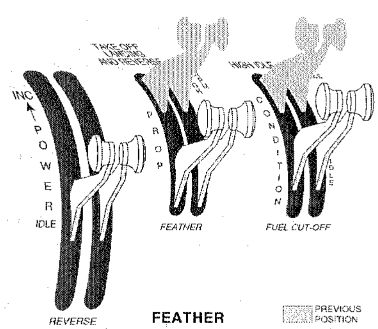
Pratt & Whitney Canada
A United Technologies Company

PROPELLER FEATHERING

Moving the Propeller Lever to the Feather position will feather the propeller by routing the oil from the propeller hub into the Reduction Gearbox.

Pilot tips

- Always feather the propeller prior to shutting down the engine, this will allow the oil from the propeller and RGB area to make its way back to the oil tank. This will give you more consistent oil levels.
- Minimize engine operation with the propeller in feather thus avoiding high oil temperature, high T5 and high nacelle temperature.

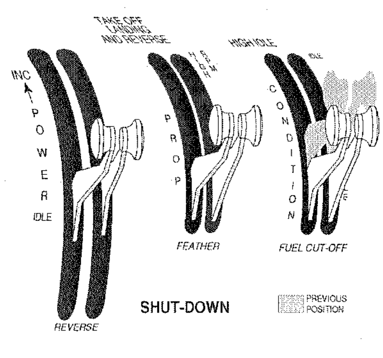


ENGINE SHUT-DOWN

Moving the Condition Lever from the Low-Idle position towards the Fuel Cut-Off position will stop the fuel delivery to engine.

Pilot tip

- Allow engine to stabilize for a **minimum** of one or two minutes at minimum obtainable ITT / T5 (2 minutes for the A-60/64/65/66/67 engines) prior to shutting down.
- Avoid propeller windmilling by restraining the propeller after engine has been shut down or when the aircraft is unattended.



Use conservative power management. Continuous effort to reduce operating costs are cumulative.

STARTING and SHUTDOWN
- Represent the largest temperature change (thermal cycling) and the turbines are mostly affected.
- Turbine blade tip rub occur during large thermal gradient (Hot Start).
- Should you keep the engine running or stop? Will affect the cycle count of the rotating components.
- Battery start and cross generator start may create hotter starts.
- Cold weather starting:
  - -40°C is the minimum starting temperature.
  - Preheat the oil tank and RGB area at low ambient temperature.
- Bottom line, the cooler the start the better it is.

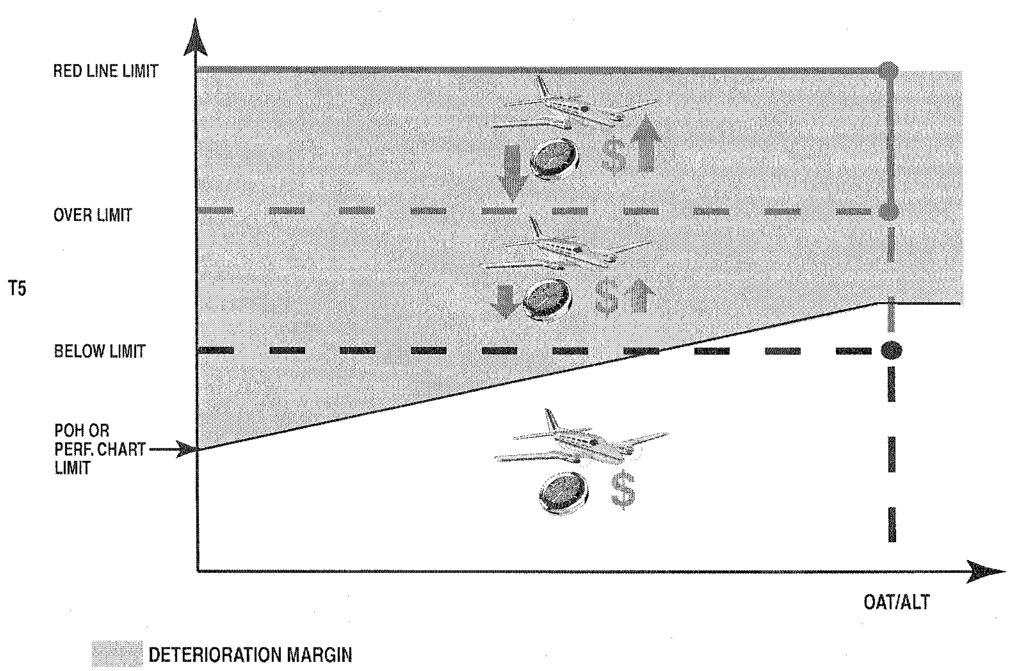
THROTTLE TECHNIQUE
- Move the throttle slowly and infrequently.
- Keep pulling levers back not forward.
- Don't "Rev up" the engine.
- Warm up the engine before using high power setting (for example: acceleration check).
- Reduce thermal shock as much as possible.

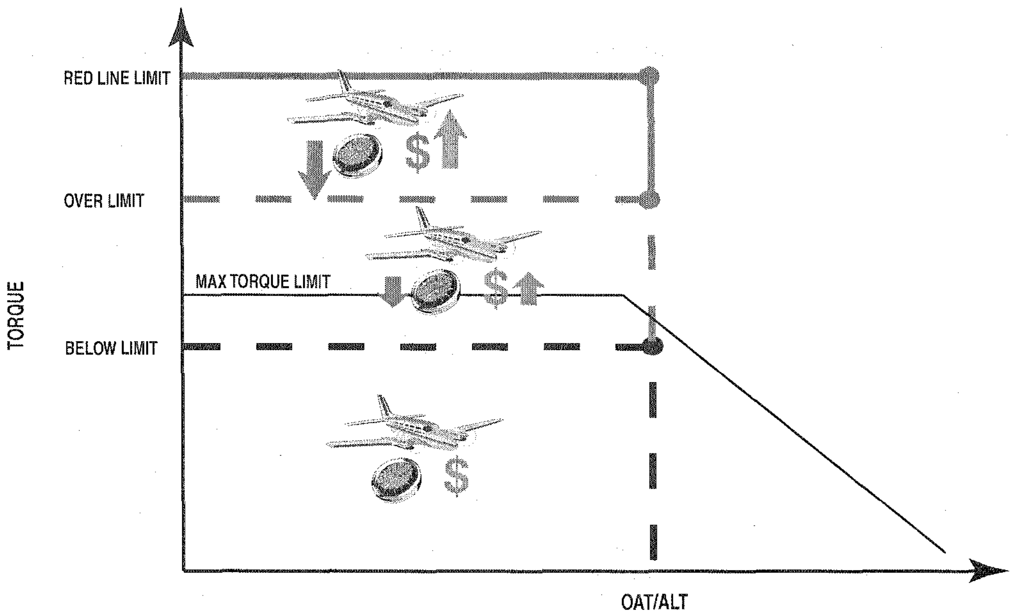
SURGE and STALL
- Throttle back if continuous surge is encountered.
- Accelerate slowly if an engine is prone to surge.
- Surge may damage the compressor and hot section.
- Have the engine/bleed valve checked.

POWER SETTING
- Set torque strictly to the POH chart.
- Do not "Redline" the engine.
- Target Torque for take-off and T5 for climb.
- Reduced power setting depending on flight condition (take-off, climb, cruise, etc.).
- Hot day (temperature limited) versus cold day (torque limited).
- Short flights versus long flights means there is more time is spent at high power.

LOW OIL PRESSURE SITUATION
- reduce the power or shutdown the engine if the oil pressure is below the green band (with the engine above 72% Ng speed).
- Example (taken from the PT6A-60A Maintenance Manual, Chapter 71-00-00, Operating Limits):
- Normal oil pressure (Ng above 72%) 90 to 135 psig
- Minimum oil pressure at Idle 60 psig
- Under emergency conditions, 60 psig is permissible below 2000 lb. ft. torque
- Below 60 psig is unsafe and requires the engine to be shut down, or landing be made as soon as possible using minimum power required to sustain flight

SHUTDOWN
- Cool down the engine prior to shutdown (1 or 2 minutes minimum at lowest achievable T5) to minimize thermal shock as well as minimize oil cocking in the bearing areas and fuel nozzle tip cocking.
- Feather the propeller prior to shutdown.



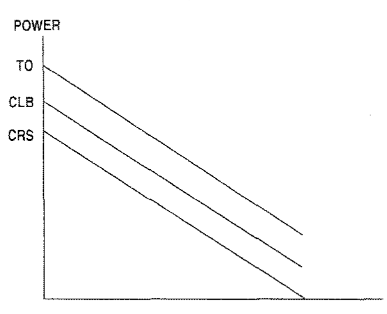


ENGINE RATING PHILOSOPHY

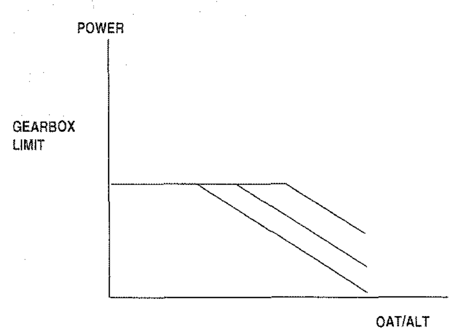
New or newly overhauled engine acceptance limits are designed to allow sufficient margin to carry the engine through the next overhaul period.

Flat rating

- Provides the aircraft manufacturer with a series of power curves.
- used to predict and evaluate engine and aircraft performance under various flight conditions.
- Graphs and tables found in the pilot operating handbook (POH) are derived from these power curves.
- Power versus outside air temperature and pressure altitude or barometric pressure.
- Flat rating.
- Temperature margin.



At constant T5,
power reduces as OAT and altitude increase.



Flat rating limits power as a function of the RGB.

- Metal is not 100% rigid.
- If enough force is applied, deformation will occur.
- Temperature only increases deformation.

- **Creep:**
  - Stretching of a part caused by a force pulling on it (centrifugal force).
  - High temperature accelerates creep.

- **High cycle fatigue (HCF)**:
  - For example: Rotor unbalance = 1 cycle per revolution).
  - Stress applied to a part that cycle at a high rate.
  - Engine design provides for HFC.

- **Low cycle fatigue (LCF)**:
  - Stress applied to a part that cycle at a low rate (for example: one start, flight and shutdown equals one full cycle).
  - Requires parts replacement **before** the life limit is exceeded (total accumulated cycle limits vary with material and application, refer to your specific SB for values and additional information).
  - The rotor component service life limitation **override** the TBO & HSI consideration.

Pilot tip:

- It is the operators responsibility to record all flights, engine starts and to track the accumulated total cycles in the applicable document for each component (i.e. logbook, LCF component card, etc.).
- When returning a module for repair, you must supply the total accumulated cycles for the each rotating components in that module to allow the components to be marked per the overhaul manual.
- The parts must be removed from service before their respective accumulated total cycle limit is reached.
- Rotor components which are not supported with proper documentation are to be removed from service.
- Operators having missions which include many touch-and-go flights or a frequency of scheduled in-flight shutdowns (such as used during pilot training) or which include more than 10 flights per hour must submit their mission profiles to Pratt and Whitney Canada for life cycle analysis.
- There is **no conversion factor** to convert engine running hours to cycles.

CHAPTER 13
SPECIAL APPLICATION

SPECIAL APPLICATIONS

This section incorporates information on devices specific to certain PT6A types.

Automatic Power Reserve (APR) (twin-engine aircraft)
In the event of an engine malfunction, this system allows the other engine to increase its Ng (subsequently power) without pilot action.

Power augmentation (twin-engine aircraft)
During Take-Off, on a hot day when water injection is used, the power augmentation system resets the fuel control unit to maintain the selected Ng speed while water is being injected. This is pilot selected.

Syncrophaser (twin-engine aircraft, airframe device)
Electromagnetic coil located in the Propeller Governor (CSU) and activated by an airframe supplied electronic control unit that synchronizes the speed and phase of the propeller blades. This system only allows for a minimal speed increase on the 'slave' unit.

Pilot tip:
- Prior to changing power settings, during Take-Off and during landing, the syncrophaser system should be disengaged to prevent instability.