POPA
June 12-14, 2014
Savannah, GA

Pratt & Whitney Canada
A United Technologies Company

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ENGINES SUPPORT INNOVATION PEOPLE

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	Classification:
1. Canadian ECL(s):	**N/A**
2. ECCN(s) (EAR):	
3. P-ECCN(s) :	**9E991**
4. USML (ITAR):	
5. P-USML:	

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AGENDA

GA Inc.

Fleet Status

Engine Performance & Power Management

Engine Maintenance Philosophy

Best Practices

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Fleet Status

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PT6A ENGINE STATISTICS

- Total Produced
  43,000 +
- Flying Population
  23,000 +
- Certified PT6A Models
  70
- Total hours flown
  355.4 Million hours
- High Time Engine
  52,502 (PT6A-65B)

PT6A ENGINE RELIABILITY
TERMINOLOGY

Key Rates

IFSD	In Flight Shut Down
BIF	Basic In Flight Shut Down
TIF	Total In Flight Shut Down
UR	Unplanned removal
BUR	Basic Unplanned Removal
TUR	Total Unplanned Removal

"Basic" – Event can be directly linked to the engine design or manufacture

"Non-Basic" – Event cannot be linked to the engine design or manufacture (e.g. weather, pilot induced, etc.)

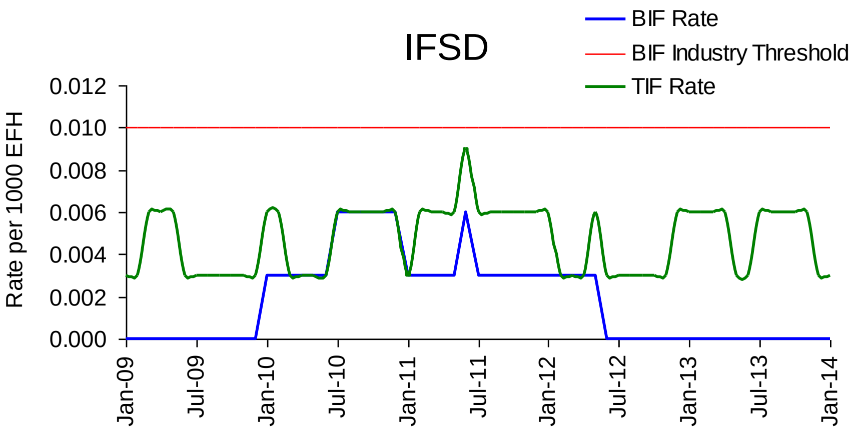
Standard is 12 month rolling average

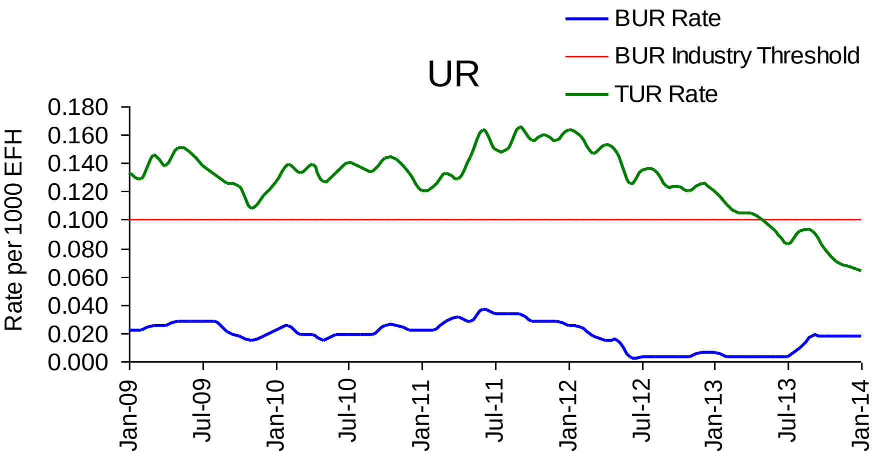
PT6A-67B SERVICE EXPERIENCE

Engine flying hours	3.67 Million
Engines in service	758
High time engine	>20,969
Basic IFSD*	0.000
BUR*	0.018

* Events / 1000 hrs (12 month rolling average)

PC-12 Legacy





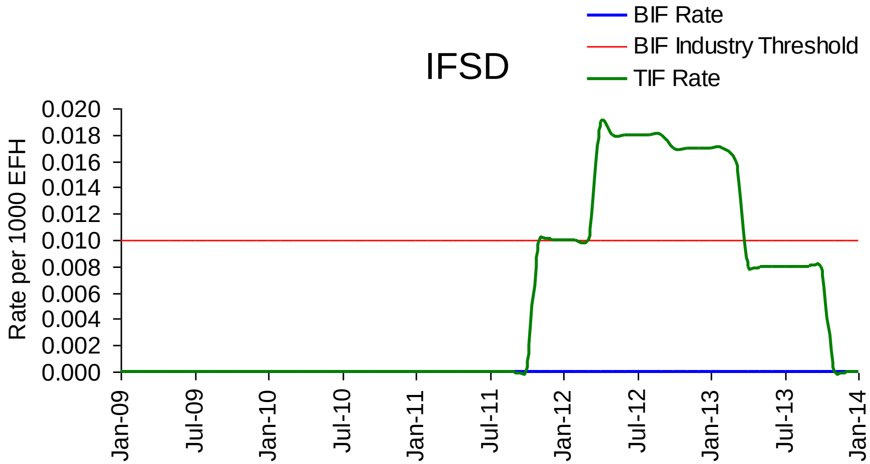
Note: Rates calculated with 12 Months Rolling Average & 3 Months Lag period

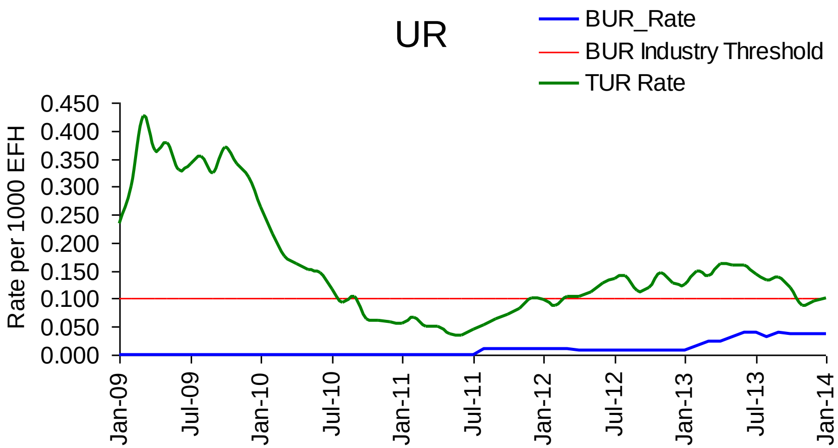
PT6A-67P SERVICE EXPERIENCE

Engine flying hours	0.52 Million
Engines in service	421
High time engine	>5,392
Basic IFSD*	0.000
BUR*	0.036

* Events / 1000 hrs (12 month rolling average)

PC-12 NG

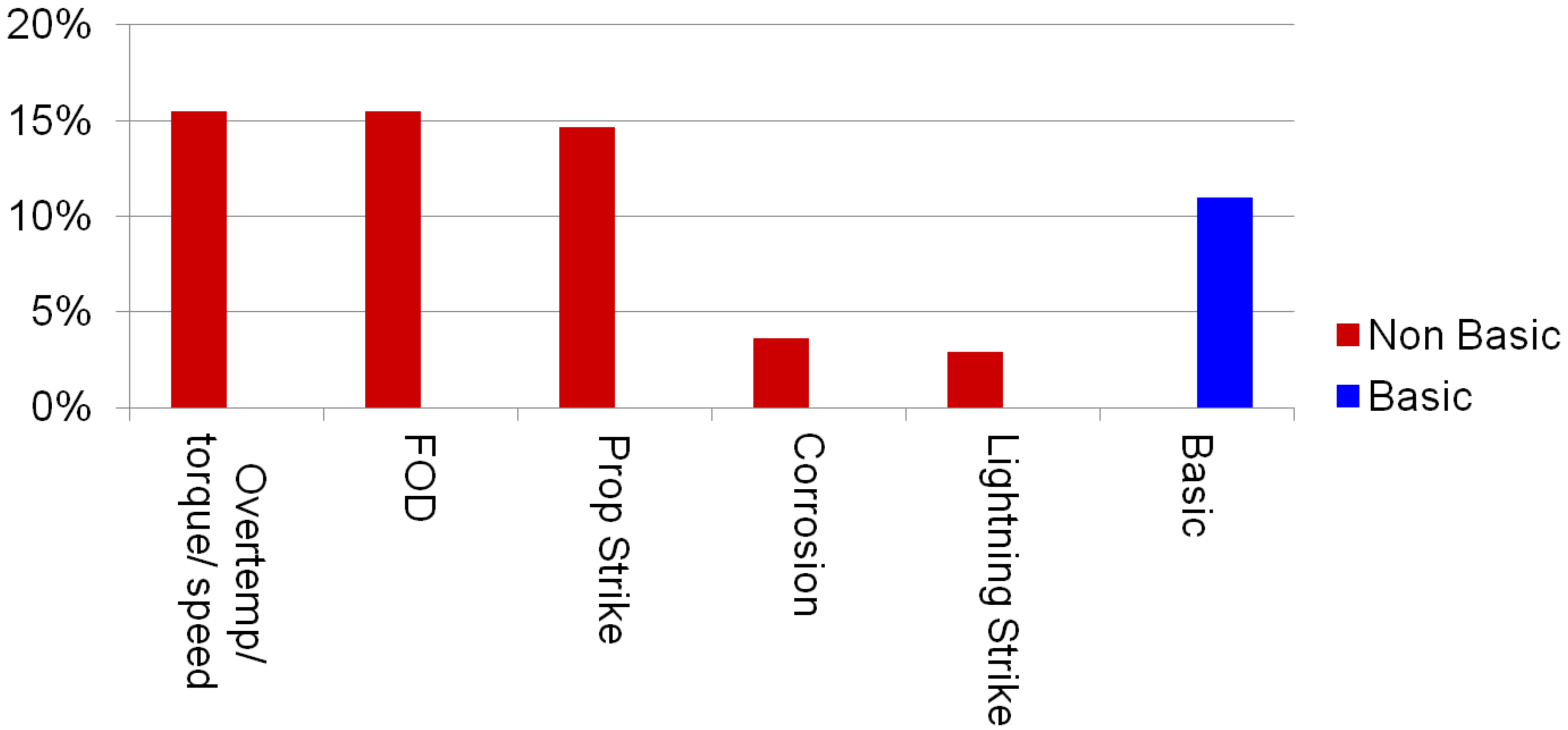




Note: Rates calculated with 12 Months Rolling Average & 3 Months Lag period

PT6A ENGINE RELIABILITY

Top Non-Basic Drivers



Maintenance And Operation Are Key

Torque Limiter Oil Leak Field Inspection Update

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Torque Limiter Oil Leak

Issue

Oil leak on windshield during decent – 24 Jan 2013, Engine RY0086 – TSN 544

Findings

Screws found loose with lockwire still intact, due to loss of screw pre-load. Indications that screws were not adequately torqued at manufacture.

Rubbing and fatigue crack evident in bellows due to resulting wear mechanism, loss of bellows retention.

Action

Quality escape process with Honeywell completed

CMM revised to specify torque value and require recording screw torque values

One time inspection SB14473

Torque Limiter Oil Leak

Try to rotate spring pivot head in a clockwise and counterclockwise direction, and report any signs of movement.

Pivot spring assembly

In-situ inspection of torque limiters that are less than 1,000 hrs of service

Two findings to date
Units being sent to P&WC for investigation with full support from supplier

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Engine Performance

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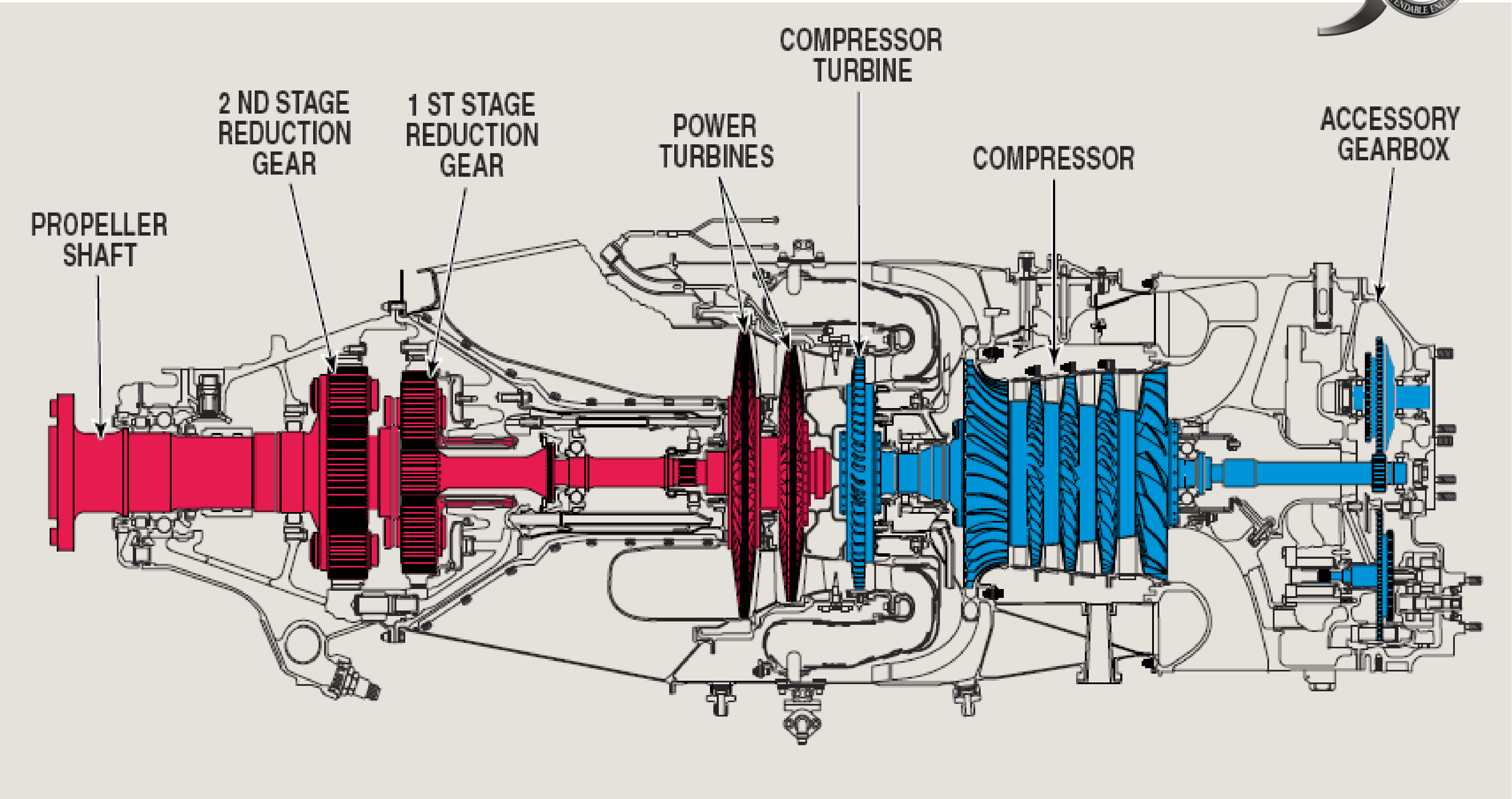
PT6A Engine Overview



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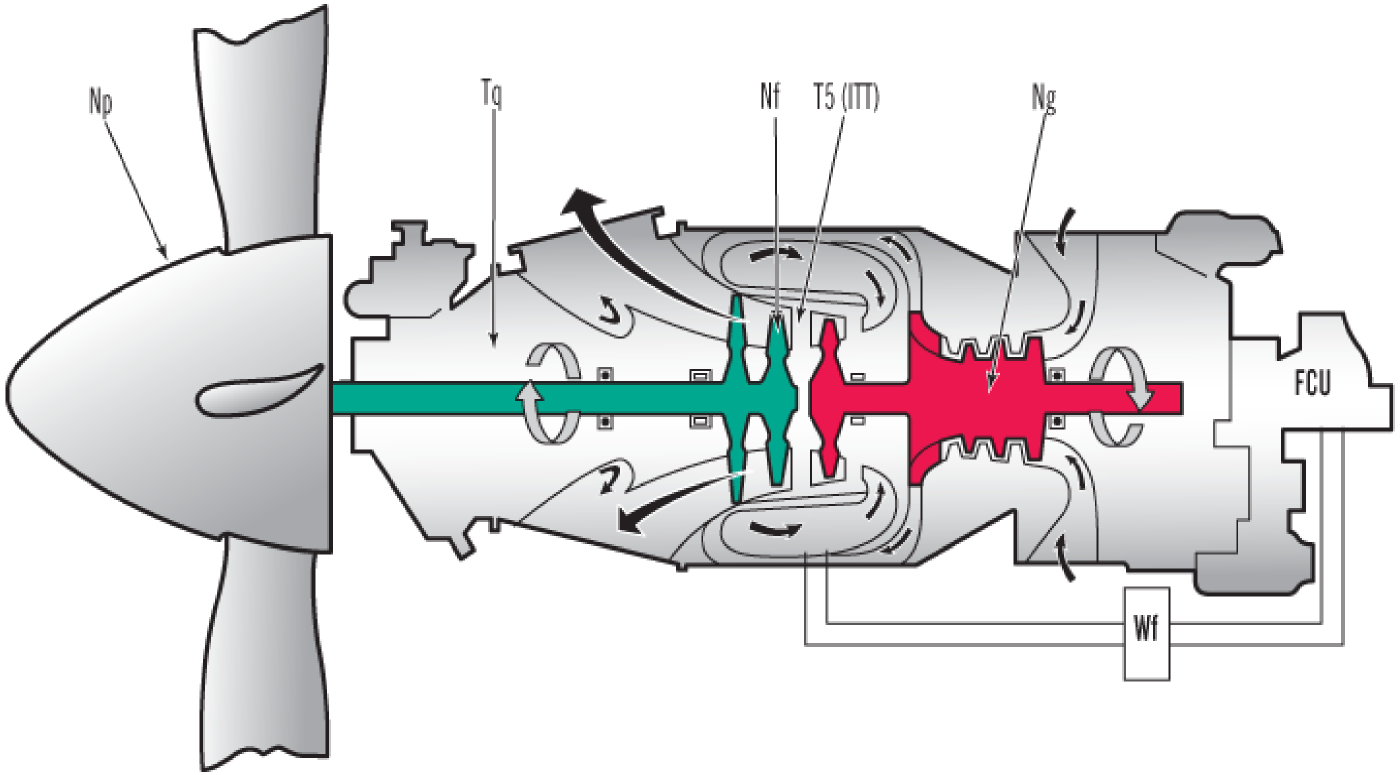
PT6A Overview

Two Spool, Free Turbine Design



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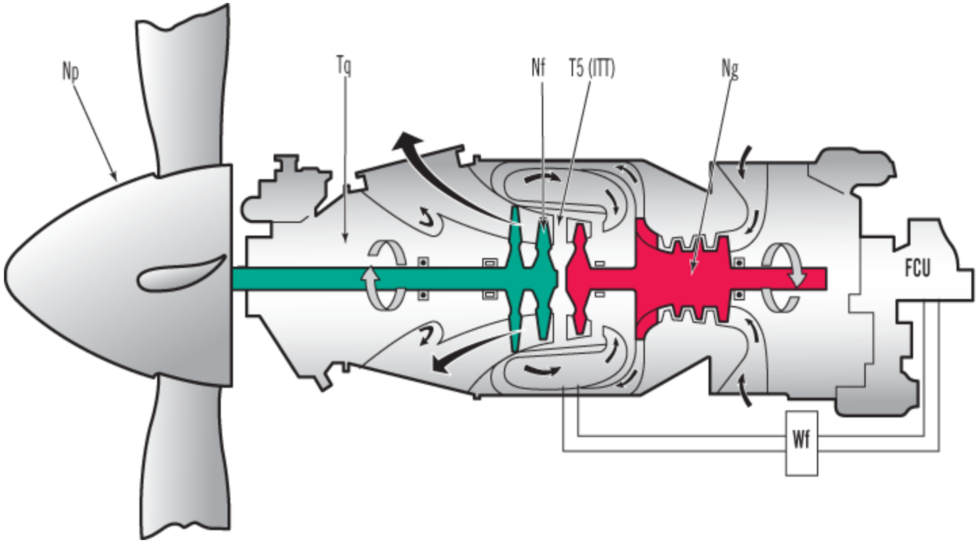
Engine Performance Check

Permits verification of engine condition over a wide range of ambient temperatures without exceeding torque or ITT limits

When should it be done?

- After engine installation
- Before and after hot section inspection
- After FCU change
- Engine troubleshooting

SIL PT6A-188



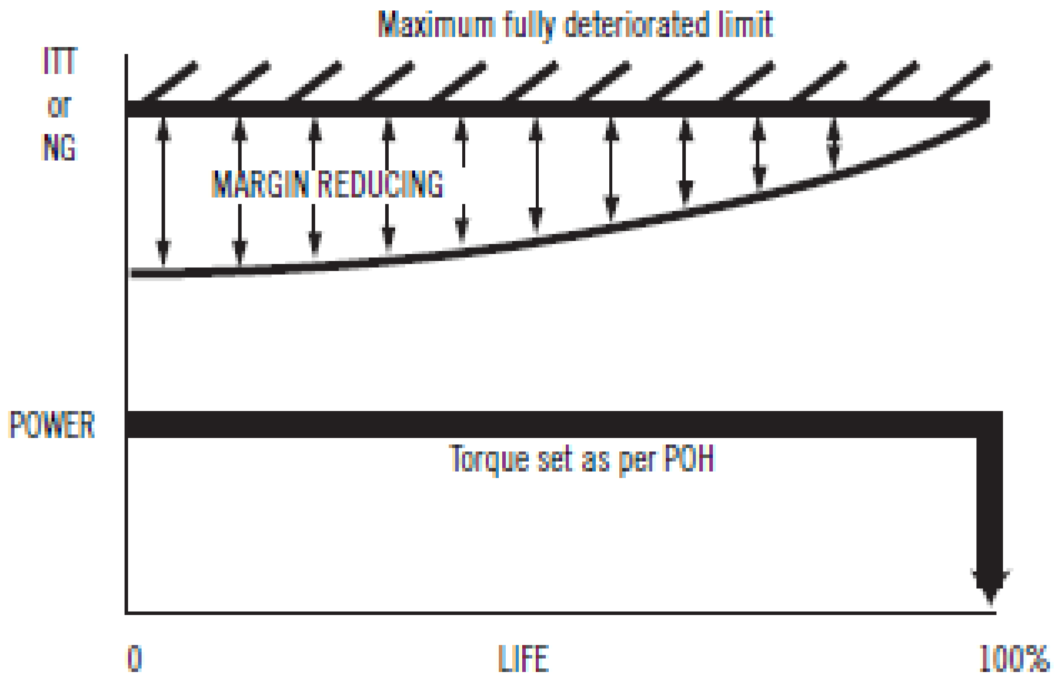
Engine Performance Check

How to measure/monitor performance

- ECTM
- Engine performance check procedure per EMM and AMM
    - Check is performed at a given power where Tq and NP are constant
    - Target Tq , ITT, Ng, Wf obtained from AMM for a given pressure Alt and temp
    - Engine run to set target torque and NP and actual ITT, Ng, Wf are compared to chart parameters
    - If values exceed chart parameters, then further troubleshooting is required
- Not a true measure of margin
- Data scatter due to ground run vs in flight

Engine Margin

Margin = Max Operating Limit – parameter @ rated power for the day



Effect on Performance

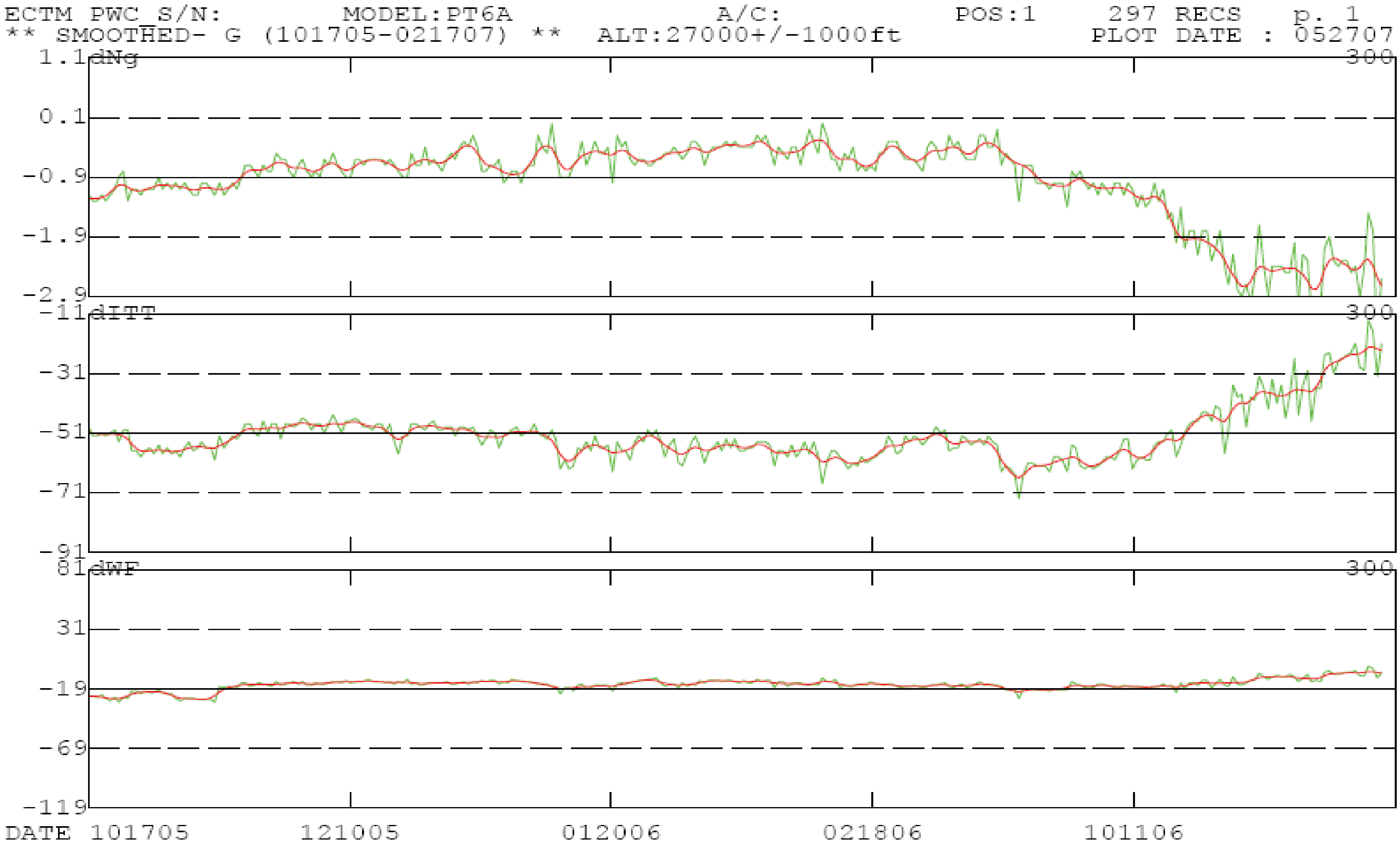
Typically picked up by trend monitoring

Compressor deterioration -	NG ↑ ITT ↑ Wf ↑
Restricted air inlet -	NG ↑ ITT ↑ Wf ↑
BOV open, or leaking valve seat -	NG ↑ ITT ↑ Wf ↑
P3 leak -	NG same, ITT ↑& Wf↑
Hot section deterioration –	NG ↓, ITT ↑ Wf ↑

- Burnt CT vane
- High CT tip clearance
- Eroded CT blades

A single engine parameter change usually means an indication issue

Trend Monitoring



PT6A Engine Power Management

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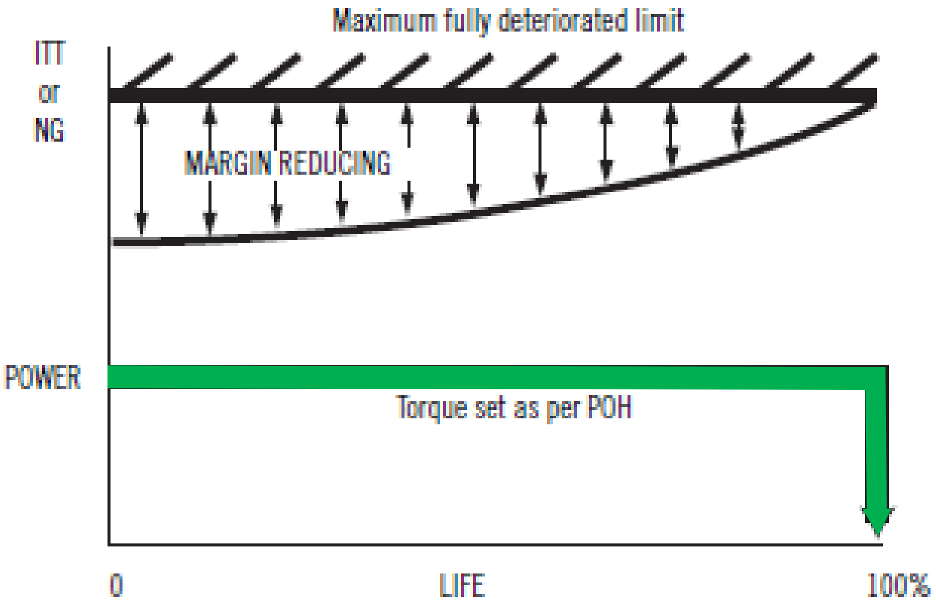
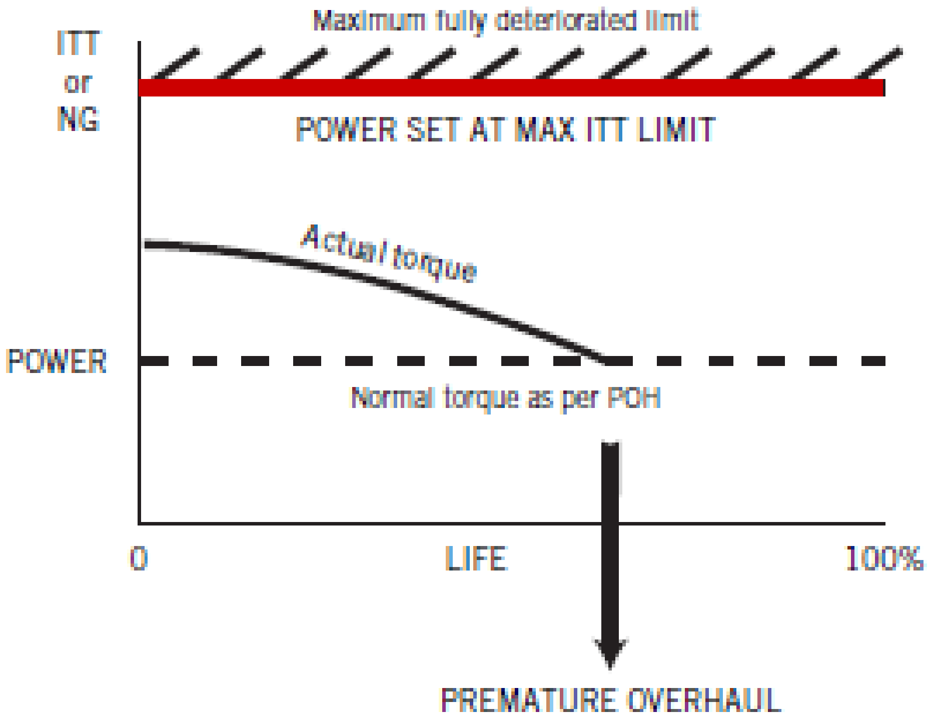
WHY TORQUE NOT TEMP?

Do you set your power to torque per POH?





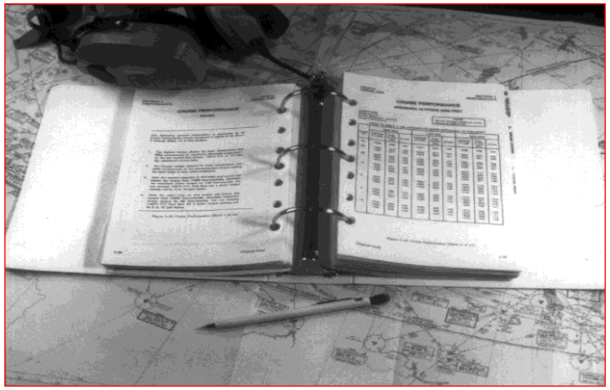
PT6A Engine Power Management

Rating Philosophy

Engine provides rated power throughout its TBO …..provided:

– Operation is in accordance with the POH
– Engine is maintained in accordance with the EMM

<u>Torque is the primary power setting parameter</u>



PT6A Engine Power Management

Engine Deterioration

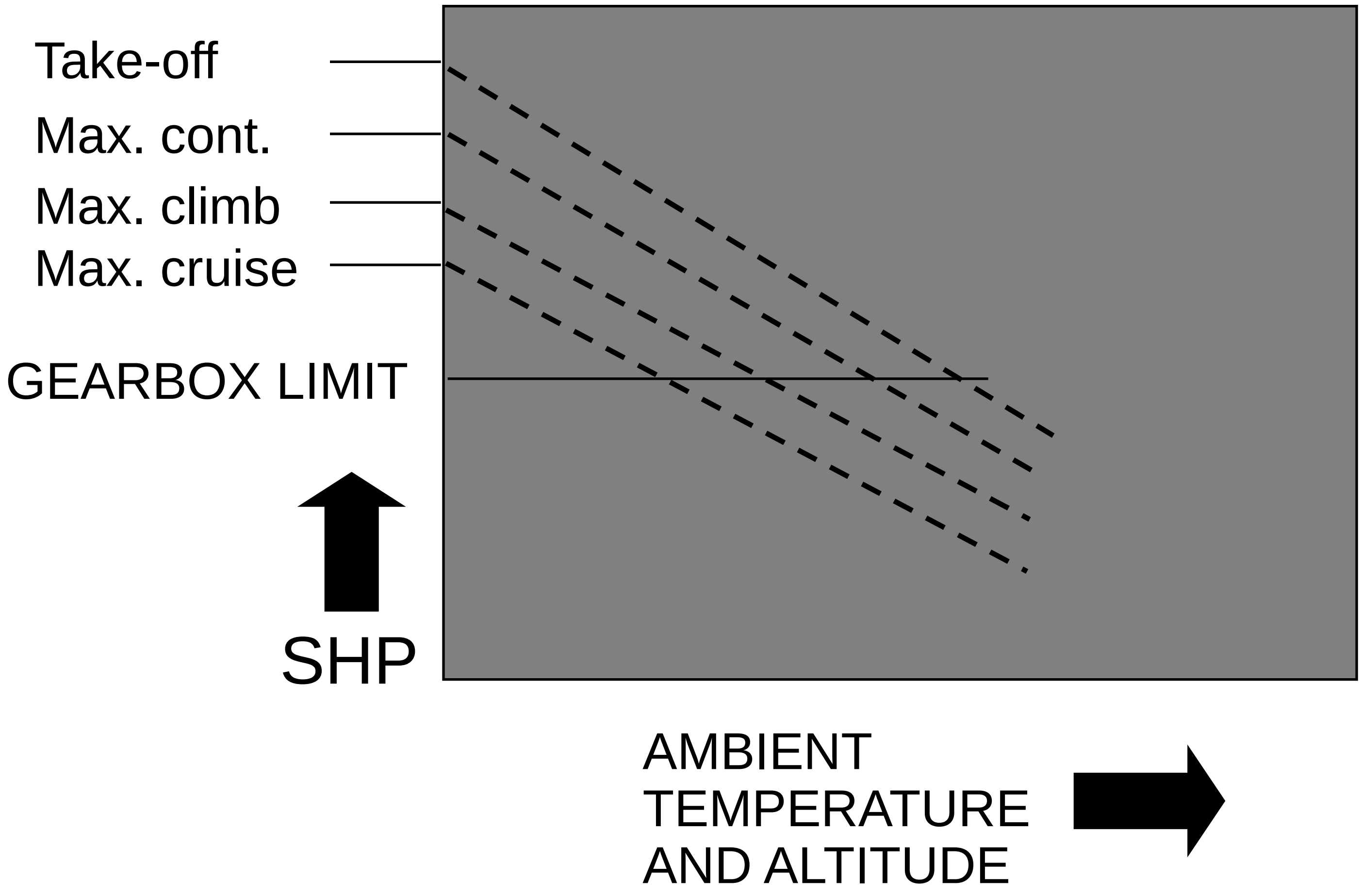
Setting power above POH Torque recommendations accelerates the normal deterioration of the engine → premature HSI / Overhaul

Can also lead to CT Blade creep

- high ITT + high Ng + time
- Change in microstructure, blade stretch leading to cracks

Flat Rating

Permits max possible take-off power required over a wide range of ambient conditions



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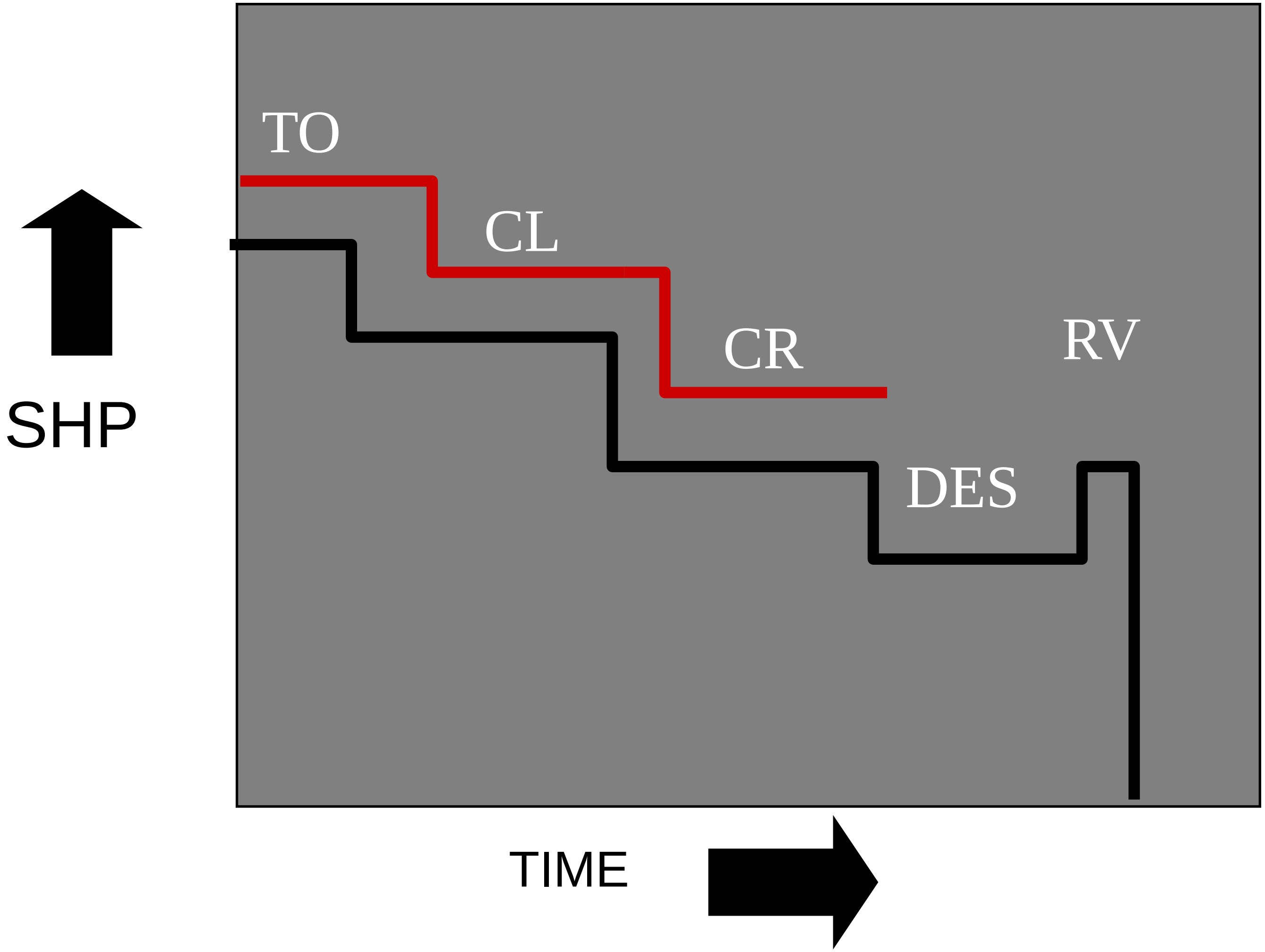
P&WC Proprietary Information

Aircraft Mission



Engine Maintenance Philosophy

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Maintenance Philosophy

Preventive Maintenance – Monitoring

- Fuel Nozzle Replacement
- Borescope Inspections
- Engine Condition Trend Monitoring - ECTM

Engine Maintenance

Fuel Nozzle Inspection / Cleaning

- Inspection is recommended at 400 hour intervals
  - Extension based on inspection results

Consequences of Poor Fuel Nozzle Maintenance

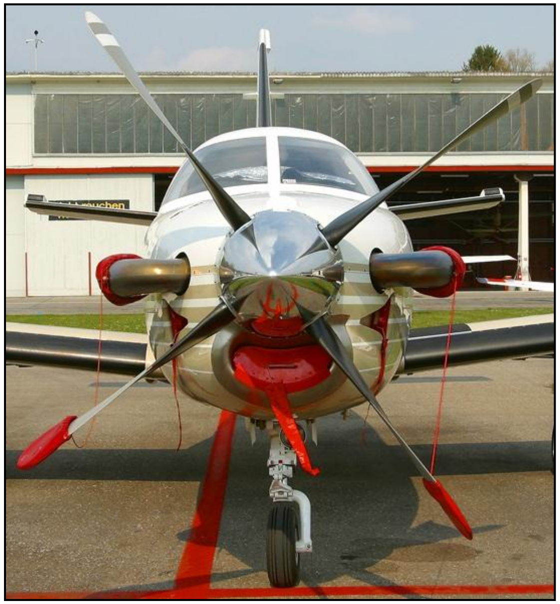
- **Cost You Money**
  - Local overheating/burning
  - Improper flame propagation
  - Combustion liner distress
  - Small exit duct burning
  - CT Vane burning
  - CT Blade distress

Can also affect your warranty claims

Hot Section Borescope Inspection

- Aligned with Fuel Nozzle Cleaning

Engine Maintenance - Preservation



Inactive
Engine is not operated on ground or in flight for a minimum of 10 minutes once oil temperature is stabilized.

Inactive for 0 to 7 days

Compressor and turbine desalination wash (salt laden environments)
Install Inlet and Exhaust Covers

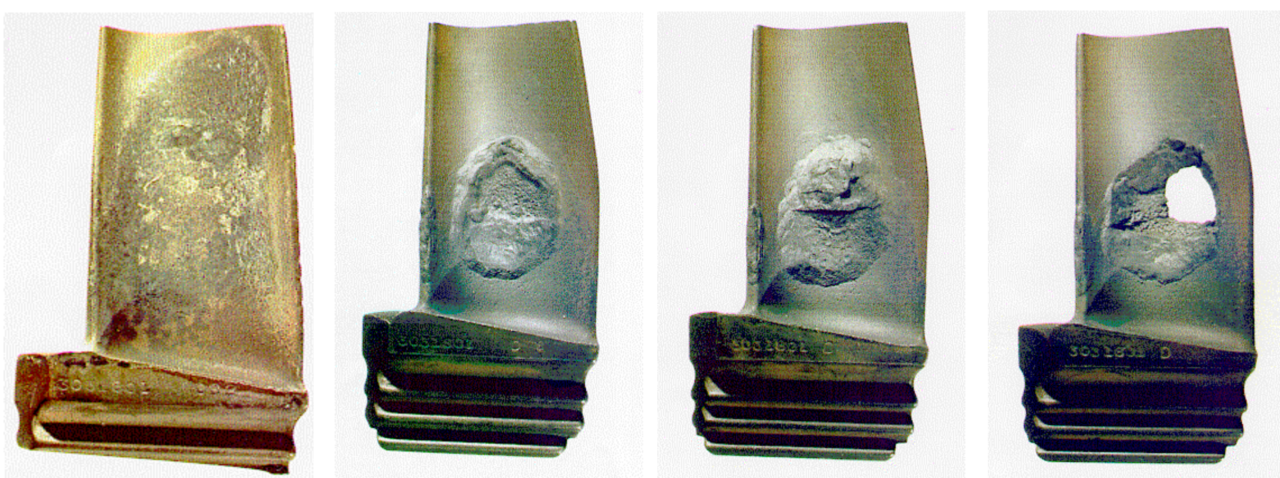
Inactive for 8 to 28 days

Do 0 to 7 day procedure
Desiccant bags and humidity indicators in exhaust
Seal all engine openings
Check relative humidity every 2 weeks, should be <=40%

Ref. EMM Chap. 72-00-00 for procedures above 28 days

Compressor and Turbine Wash

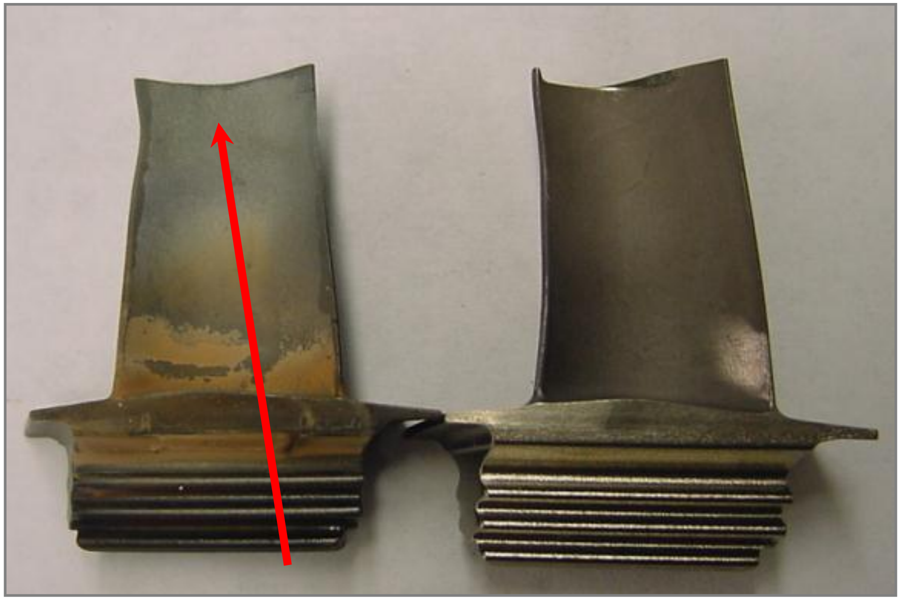
Effective way to prevent inlet case, compressor and turbine corrosion – SIL PT6A-206



SIL-125 Inadvertent Cutoff & Relights and POH

- SIL PT6A-125 Operational awareness
  - Blade microstructure damage due to overtemp caused by accidental cut-off & relight
  - Acceleration of Blade creep due to use of more power than allowed by POH
  - Issued January 2004
- Revised Maintenance Manual April, 2004
  - Address accidental cut-off & relight overtemp
  - Lessons learned applied across all PT6A Maintenance Manuals

SIL PT6A-125 CT Blade Fractures



Accelerated Blade Creep

It is essential to use the correct power setting procedures to assure the integrity of the engine.

Engines operated regularly beyond the recommended power settings of the POH, but still below the defined temperature redline settings and EMM over-temperature chart limits, may experience accelerated CT Blade Creep.

Operational Best Practices

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It is All About Temperature …

STARTING :

General Rule : The Cooler, The Better !!!

ASSISTED START :

- Experience has shown that Ground Power Unit (GPU) assisted starts are cooler.

It is All About Temperature …

STARTING :

General Rule : The Cooler, The Better !!!

BLEED OFF DURING START:

- Selecting bleed off at engine start decreases the maximum starting temperature.
- Reducing peak temperatures will have a direct impact on blade life.

It is All About Temperature …

TAXIING :

Use of Reverse Power :

- Use of reverse power to push back the aircraft from the ramp increases engine operation temperature.
- Park aircraft away from the ramp if push-back carts are not available.

It is All About Temperature …

CLIMBING / CRUISE :

Climb Setting :

- Select CLIMB setting on Power Lever at earliest opportunity based on obstacle clearance.
- This will reduce engine operation time at high temperatures. **Refer to AFM / POH**

It is All About Temperature …

CLIMBING / CRUISE :

Reduced Power Operation :

- Where operations permit, most benefit is achieved by reducing power and ITT during climb and cruise.
- By reducing power (derated operation), the cumulative deterioration done to a component during the interval between refurbishments may be reduced.

Refer to AFM / POH

It is All About Temperature …

LANDING / SHUTTING DOWN :

Use of Reverse Power :

- Use of full reverse power increases engine operation temperature
- PCL to Beta (flat pitch) sufficient
- Limiting the use of reverse to necessary cases only, will contribute to increased hot section life.

It is All About Temperature …

LANDING

Propeller Flat Pitch at Landing :

- When landing, especially on an unpaved runways it is recommended to use flat pitch (disking) and not full reverse.
- This will reduce the possibility of foreign object ingestion and consequential FOD damage to compressor.
- In addition, disking will not increase engine operation temperature to the extent of full reverse.

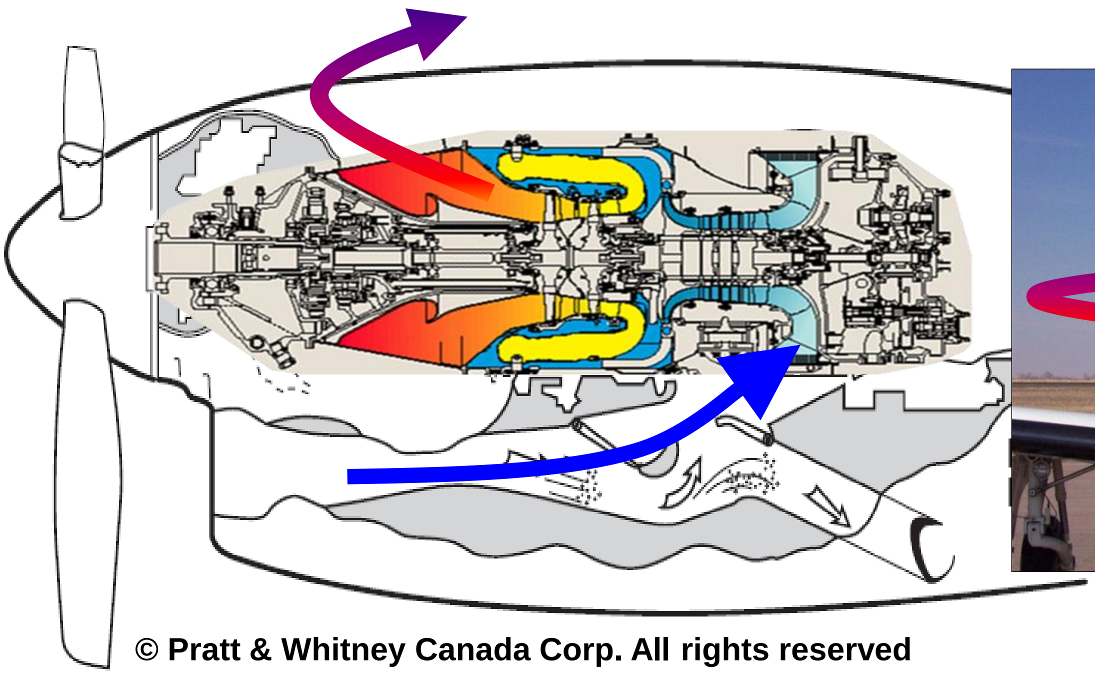
It is All About Temperature …

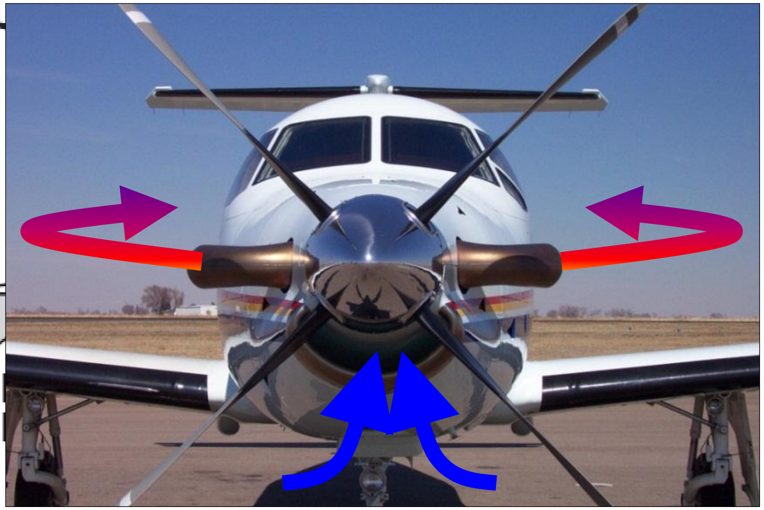
LANDING / SHUTTING DOWN :

Cool Down Before Shutdown :

- An engine cool down period of two minutes at GI (ground idle) prior to shutdown will assist hot section temperature equalization.
- Reduces residual heat build-up in the engine/nacelle
- Reduces the level of fuel nozzle coking.

FOD & Ice Protection





FOD PREVENTION

General

Use inertial separator during taxi operation and icing conditions

Check that the tarmac is clean during walk-around

Avoid dropping safety wire or rivets in the air inlet plenum area

Install inlet / exhaust covers when aircraft not in use

Do not use reverse thrust at low ground speed

What damages the prop may damage the compressor

Damage example
1st stage Compressor

FOD PREVENTION

First Stage rotor icing damage

First Stage rotor icing damage

- First stage blade bending is consistent with an impact from a soft body that could be related to formation of ice

Preventive Field Actions

- Troubleshooting chart improvement made to add unusual compressor high pitch noise to trigger maintenance action
- Add a periodic inspection for visual borescope inspection on First Stage Rotor

Q: When should the inertial separator be activated?

A: Check the POH.

FOD PREVENTION

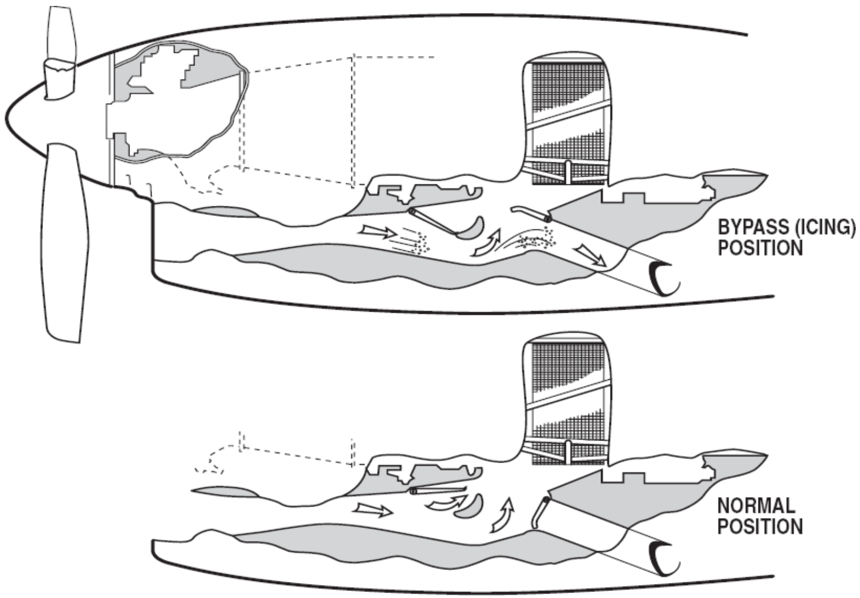
Inertial Separator Operation

Ground

- Avoid starts with separator open
- Watch ITT closely during deployment

Flight

- Reduce power by 10% before deployment
- Allow for deployment time before entering icing conditions
- Watch ITT closely during deployment



ITT EXCEEDANCES

Main Causes

Adding Fuel too early - 13% Ng Min

Inertial Separator deployment in flight with no reduction in power

Taxiing in Ground Idle with bleed ON / inertial separator ON

- Compressor loading drives Ng down, ITT up
- Lower Ng means less cooling air for hot section components

Low Battery Power

ITT EXCEEDANCES

Always refer to the EMM for the required actions

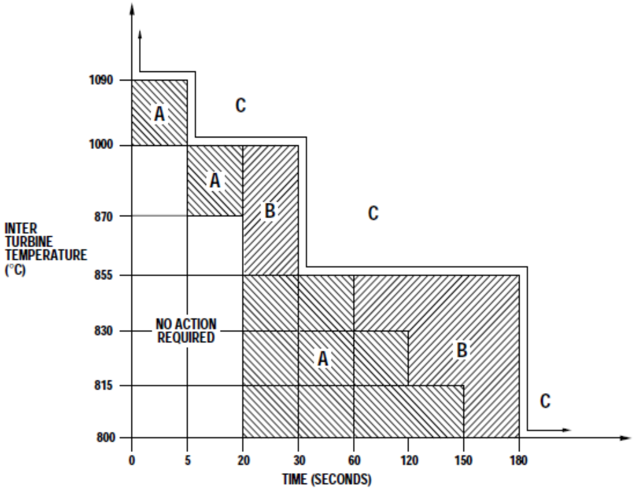
Area A:

- Determine and correct cause of O/T
- For start O/T, perform visual inspection through exhaust duct
- Record in log book

Area B: Perform Hot Section Inspection

Area C:

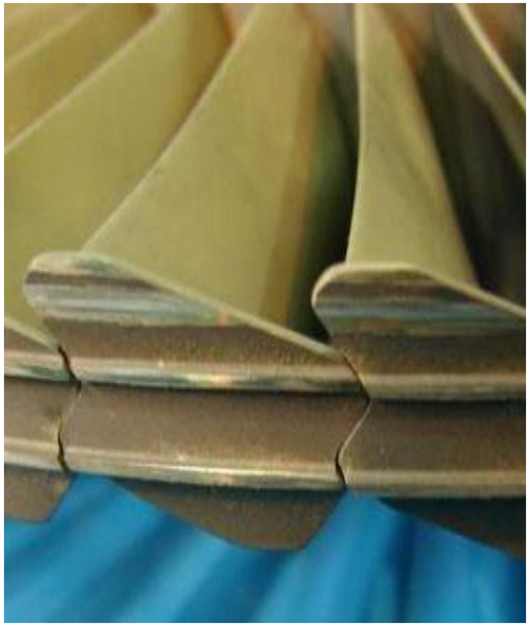
Ship Engine to approved overhaul facility for light overhaul inspection due to overtemperature



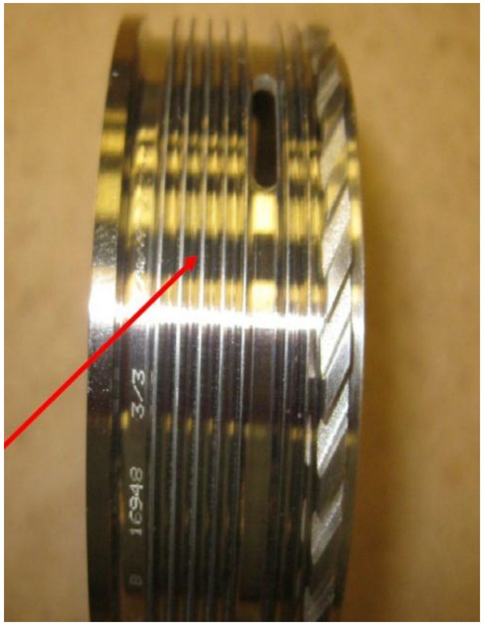
Temperature Limits

PROPELLER STRIKE

Potential secondary damage



Power Turbine tip rubbing



Labyrinth air seal rubbing

PT6A ENGINE MAINTENANCE

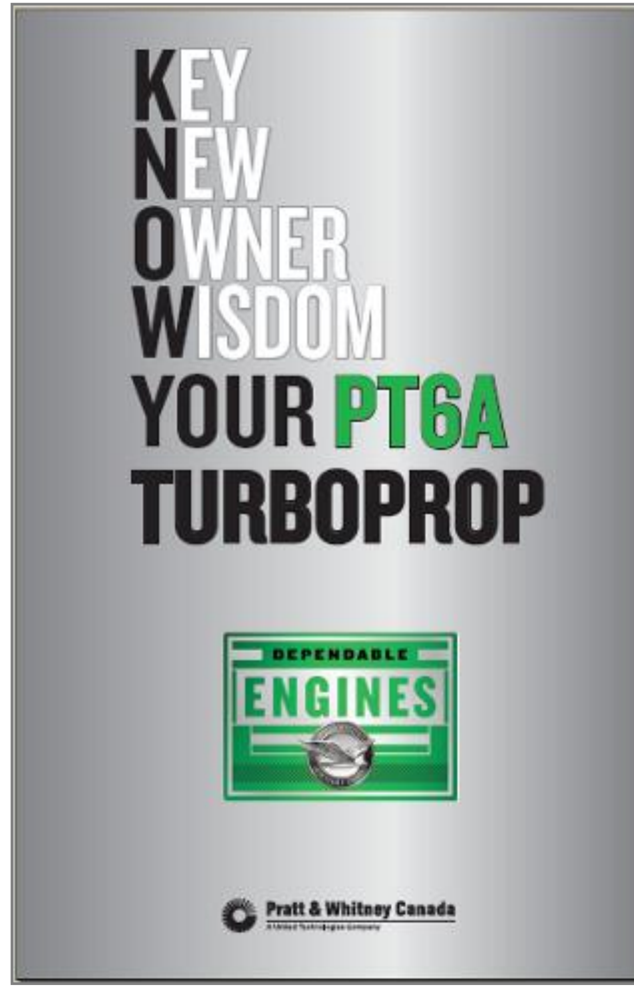
“Know Your PT6A Turboprop”

Booklet released with “need to know” information

-Now Available at www.pwc.ca

Engines → Turboprops →PT6A

→ Related Info (bottom right)

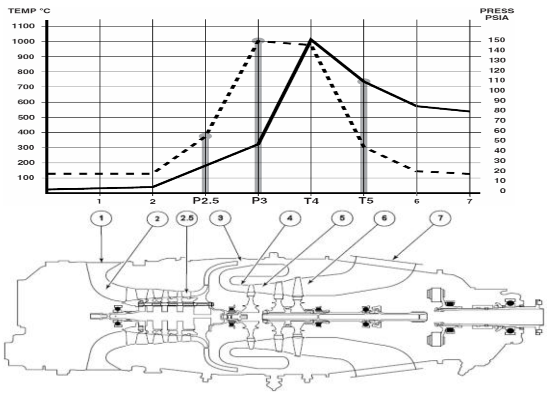


RELATED INFO

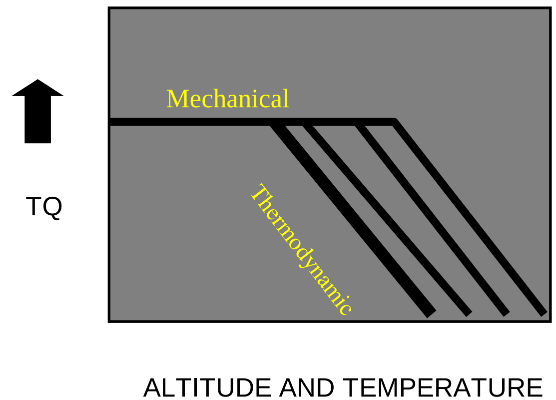
- Warranty Programs
- Customer First Centre
- Service Facilities
- Technical Publications
- Maintenance Programs
- Know your PT6A

Summary

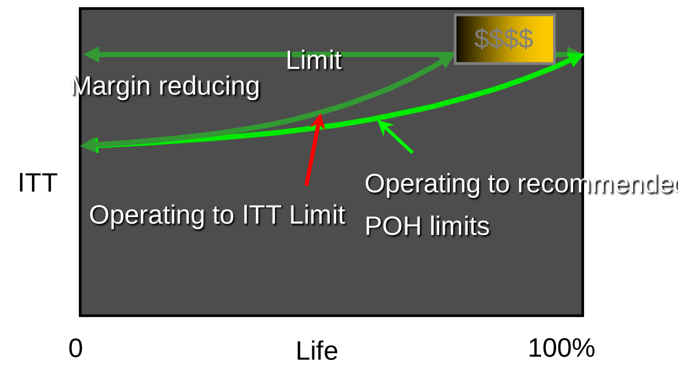
High Temperature Pressure Inside Engine



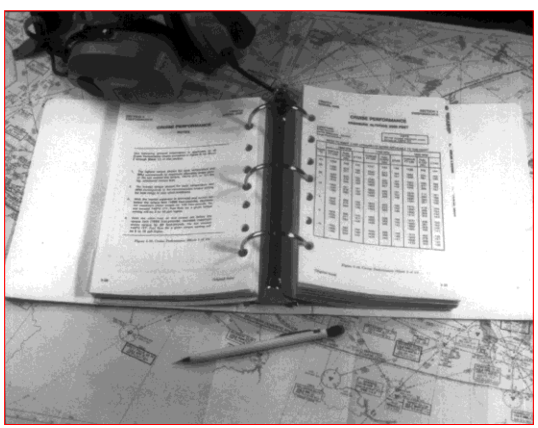
Engine has Limits



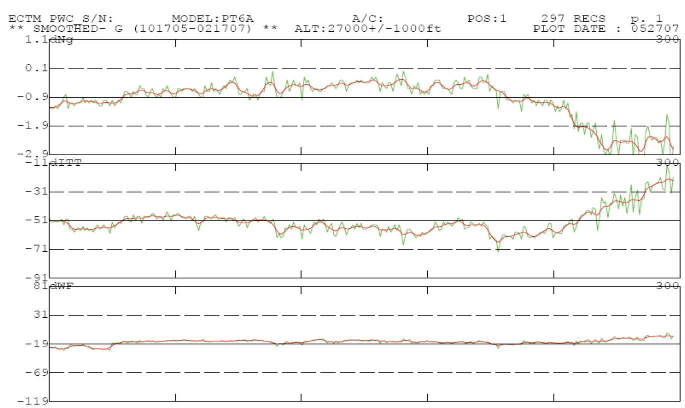
Engine Stress Costs Money



Follow EMM / POH



Monitor Engine Parameters



Save Money !