AIRPLANE TURBOPROP ENGINES
BASIC FAMILIARIZATION

INTRODUCTION

Many of today's airplanes are powered by turboprop engines. These engines are quite reliable, providing years of trouble-free service. However, because of the rarity of turboprop engine malfunctions, and the limitations of simulating those malfunctions, many flight crews have felt unprepared to diagnose engine malfunctions that have occurred.

The purpose of this text is to provide straightforward material to give flight crews the basics of airplane engine operational theory. This text will also provide pertinent information about malfunctions that may be encountered during the operation of turboprop-powered airplanes.

It is not the purpose of this text to supersede or replace more detailed instructional texts or to suggest limiting the flight crew's understanding and working knowledge of airplane turbine engine operation and malfunctions to the topics and depth covered here. Upon completing this material, flight crews should understand that some engine malfunctions can feel and sound more severe than anything they have ever experienced; however, the airplane is still flyable, and the first priority of the flight crew should remain "fly the airplane."

PROPULSION

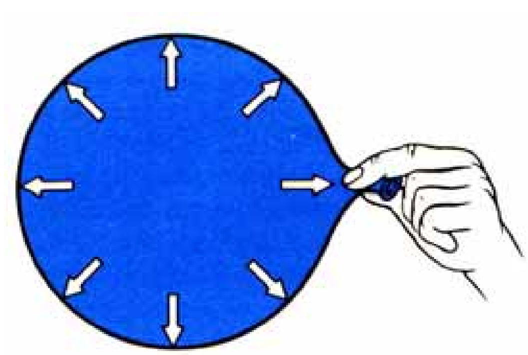

Figure 1 showing balloon with no escape path for the air inside. All forces are balanced.

Propulsion is the net force that results from unequal pressures. Gas (air) under pressure in a sealed container exerts equal pressure on all surfaces of the container; therefore, all the forces are balanced and there are no forces to make the container move.

If there is a hole in the container, gas (air) cannot push against that hole and the gas escapes. While the air is escaping and there is still pressure inside the container, the side of the container opposite the hole has pressure against it. Therefore, the net pressures are not balanced and there is a net force available to move the container. This force is called ***thrust.***

The simplest example of the propulsion principle is an inflated balloon (container) where the stem is not closed off. The pressure of the air inside the balloon exerts forces everywhere inside the balloon. For every force, there is an opposite force, on the other side of the balloon, except on the surface of the balloon opposite the stem. This surface has no opposing force since air is escaping out the stem. This results in a net force that propels the balloon away from the stem. The balloon is propelled by the air pushing on the FRONT of the balloon.

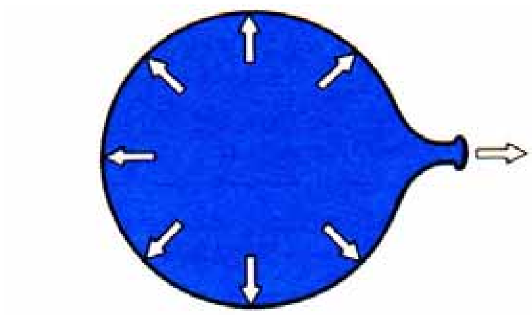

Figure 2 showing balloon with released stem. Arrow showing forward force has no opposing arrow.

The simplest propulsion engine

The simplest propulsion engine would be a container of air (gas) under pressure that is open at one end. A diving SCUBA tank would be such an engine if it fell and the valve was knocked off the top. The practical problem with such an engine is that, as the air escapes out the open end, the pressure inside the container would rapidly drop. This engine would deliver propulsion for only a limited time.

The turbine engine

A turbine engine is a container with a hole in the back end (tailpipe or nozzle) to let air inside the container escape and, thus, provide propulsion. Inside the container is turbomachinery to keep the container full of air under constant pressure. A turboprop engine extracts energy from the escaping air to drive a propeller.

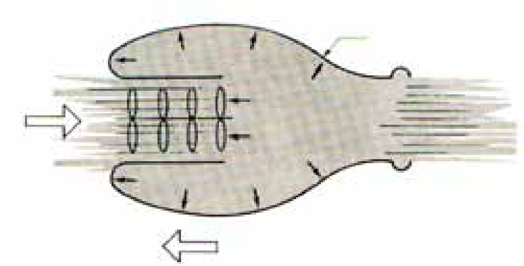

Figure 3 showing our balloon with machinery in front to keep it full as air escapes out the back for continuous thrust.

COMPONENTS OF A TURBINE ENGINE

The turbomachinery in the engine uses energy stored chemically as fuel. The basic principle of the airplane turbine engine is identical to any and all engines that extract energy from chemical fuel. The basic 4 steps for any internal combustion engine are:

1. Intake of air (and possibly fuel).
2. Compression of the air (and possibly fuel).
3. Combustion, where fuel is injected (if it was not drawn in with the intake air) and burned to convert the stored energy.
4. Expansion and exhaust, where the converted energy is put to use.

These principles are exactly the same ones used to make a lawn mower or automobile engine run.

In the case of a piston engine, such as the engine in a car or lawn mower, the intake, compression, combustion, and exhaust steps occur in the same place (the cylinder head) at different times as the piston goes up and down.

In the turbine engine, however, these same four steps occur at the same time but in different places. As a result of this fundamental difference, the turbine has engine sections called:

1. The inlet section
2. The compressor section
3. The combustion section
4. The exhaust section.

The practical axial flow turbine engine

The turbine engine in an airplane has the various sections stacked in a line from front to back. As a result, the engine body presents less drag to the airplane as it is flying. The air enters the front of the engine and passes essentially straight through from front to back. On its way to the back, the air is compressed by the compressor section. Fuel is added and burned in the combustion section, then the air is exhausted through the exit nozzle.

The laws of nature will not let us get something for nothing. The compressor needs to be driven by something in order to work. Just after the burner and before the exhaust nozzle, there is a turbine that uses some of the energy in the discharging air to drive the compressor and – most importantly for propulsion – the propeller. There is a long shaft connecting the turbine to the compressor ahead of it, and the propeller at the front.

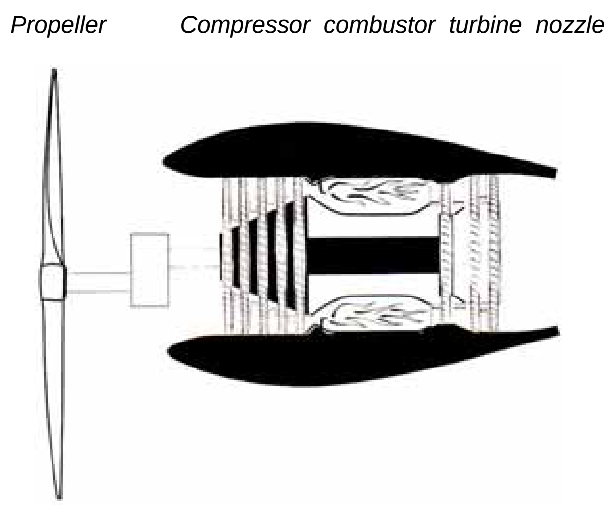

Figure 4 showing the basic layout of a turboprop propulsion system.

Machinery details

From an outsider's view, the flight crew and passengers rarely see the actual engine. What is seen is a large elliptically-shaped pod hanging from the wing or attached to the airplane fuselage toward the back of the airplane. This pod structure is called the nacelle or cowling. The engine is inside this nacelle.

The propeller is outside the front end of the nacelle, and the air passes through the propeller first. Most of the air is driven back by the propeller outside the engine nacelle; it never encounters the rest of the engine. The air near the propeller hub flows back to encounter the inlet cowl. The purpose of the inlet cowl is to direct the incoming air evenly across the inlet of the engine. The shape of the interior of the inlet cowl is very carefully designed to guide this air.

The first component that air encounters on its way through an airplane turbine engine is the compressor. The compressor of an airplane turbine engine has quite a job to do. The compressor has to take in an enormous volume of air and compress it to $1/10^{th}$ or $1/15^{th}$ of the volume it had outside the engine. This volume of air must be supplied continuously, not in pulses or periodic bursts.

The compression of this volume of air is accomplished by a rotating disk containing many airfoils, called blades, set at an angle to the disk rim. Each blade is close to the shape of a miniature propeller blade, and the angle at which it is set on the disk rim is called the angle of attack. This angle of attack is similar to the pitch of a propeller blade or an airplane wing in flight. As the disk with blades is forced to rotate by the turbine, each blade accelerates the air, pumping the air behind it. The effect is similar to a household window fan. After the air passes through the blades on a disk, the air will be accelerated rearward and also forced circumferentially around in the direction of the rotating disk. Any tendency for the air to go around in circles is counterproductive, so this tendency is corrected by putting another row of airfoils behind the rotating disk. This row is stationary and its airfoils are at an opposing angle.

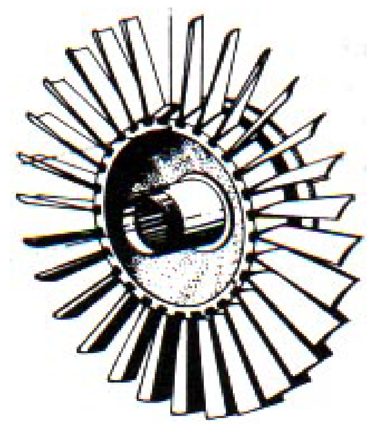

Figure 5 showing compressor rotor disk.

What has just been described is a single stage of compression. Each stage consists of a rotating disk with many blades on the rim, called a rotor stage, and, behind it, another row of airfoils that is not rotating, called a stator. Air on the backside of this rotor/stator pair is accelerated rearward, and any tendency for the air to go around circumferentially is corrected.

A single stage of compression can achieve perhaps 1.5:1 or 2.5:1 decrease in the air's volume. Compression of the air increases the energy that can be extracted from the air during combustion and exhaust (which provides the thrust). In order to achieve the 10:1 to 15:1 total compression needed for the engine to develop adequate power, the engine is built with many stages of compressors stacked in a line. Depending upon the engine design, there may be as many as 10 to 15 stages in the total compressor.

As the air is compressed through the compressor, the air increases in velocity, temperature, and pressure. Air does not behave the same at elevated temperatures, pressures, and velocities as it does in the front of the engine before it is compressed. In particular, this means that the speed that the compressor rotors must have at the back of the compressor is different than at the front of the compressor. If we had only a few stages, this difference could be ignored; but, for 10 to 15 compressor stages, it would not be efficient to have all the stages rotate at the same speed.

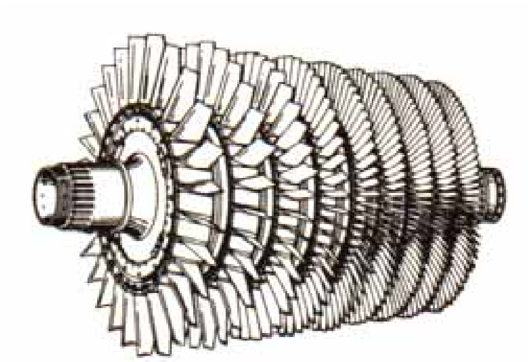

Figure 6 showing 9 stages of an axial compressor rotor assembly.

The most common solution to this problem is to break the compressor in two. This way, the front 4 or 5 stages can rotate at one speed, while the rear 6 or 7 stages can rotate at a different, higher, speed. To accomplish this, we also need two separate turbines and two separate shafts.

Most of today's turbine engines are dual-rotor engines, meaning there are two distinct sets of rotating components. The rear compressor, or high-pressure compressor, is connected by a hollow shaft to a high-pressure turbine. This is the high rotor, sometimes called the gas generator. The rotors are sometimes called spools, such as the "high spool." In this text, we will use the term rotor. The high rotor is often referred to as NG for short. (There is additional material in this package that describes single-shaft engine design.)

Moving from front to rear, the rotating assemblies are: the low-pressure compressor, the high pressure compressor, and high pressure turbine (gas generator), the low pressure turbine (power turbine) driving the low pressure compressor by a long shaft down the engine centerline (and the propeller via a reduction gearbox). The low-pressure rotor is called NP for short.

The NG and NP rotors are not connected mechanically in any way. There is no gearing between them. As the air flows through the engine, each rotor is free to operate at its own efficient speed. These speeds are all quite precise and are carefully calculated by the engineers who designed the engine. The speed in RPM of each rotor is often displayed on the engine flight deck and identified by gages or readouts labeled NP RPM and NG RPM. Both rotors have their own redline limits.

In some engine designs, the NP and NG rotors may rotate in opposite directions, or there may be three rotors instead of two, or part of the compressor may be a centrifugal compressor rather than an axial compressor. Whether or not these conditions exist in any particular engine are engineering decisions and are of no consequence to the pilot.

The turboprop engine

A turboprop engine is simply a turbine engine where a propeller is attached to the low-pressure rotor at the front, via a gearbox. The air that passes through the propeller near its inner diameter also passes through the compressor stages in the core of the engine and is further compressed and processed through the engine cycle. The air that passes through the outer diameter of the propeller does not pass through the core of the engine, but instead passes along the outside of the nacelle. The large volume of air pushed backward by the propeller provides airplane thrust in the same way as the smaller, high velocity air from the nozzle of a classic jet engine.

ENGINE MALFUNCTIONS

To provide effective understanding of and preparation for the correct responses to engine in-flight malfunctions, this section will describe turboprop engine malfunctions and their consequences in a manner that is generally applicable to turboprop-powered airplanes. These descriptions, however, do not supersede or replace the specific instructions that are provided in the Airplane Flight Manual and appropriate checklists.

Compressor surge

In modern turboprop engines, compressor surge is a rare event. A surge from a turboprop engine is the result of instability of the engine's operating cycle. Compressor surge may be caused by engine deterioration, it may be the result of ingestion of birds or ice, or it may be the final symptom from a “severe engine damage” type of failure. The operating cycle of the turbine engine consists of intake, compression, combustion, and exhaust, which occur simultaneously in different places in the engine. The part of the cycle susceptible to instability is the compression phase. In a turbine engine, compression is accomplished aerodynamically as the air passes through the stages of the compressor, rather than by confinement, as is the case in a piston engine. The air flowing over the compressor airfoils can stall just as the air over the wing of an airplane can. When this airfoil stall occurs, the passage of air through the compressor becomes unstable and the compressor can no longer compress the incoming air. The high-pressure air behind the stall further back in the engine escapes forward through the compressor and out the inlet.

This escape is sudden, rapid and often quite audible as a bang. Engine surge can be accompanied by a visible flash forward out the inlet and rearward out the tailpipe. Instruments may show high ITT and EPR or rotor speed changes; but, in many stalls, the event is over so quickly that the instruments do not have time to respond.

Once the air from within the engine escapes, the reason(s) for the instability may self-correct and the compression process may re-establish itself. A single surge and recovery will occur quite rapidly, usually within fractions of a second. Depending on the reason for the compressor instability, an engine might experience:

1. A single self-recovering surge
2. Multiple surges prior to self-recovery
3. Multiple surges requiring pilot action in order to recover
4. A non-recoverable surge.

For complete, detailed procedures, flight crews must follow the appropriate checklists and emergency procedures detailed in their specific Airplane Flight Manual. In general, however, during a single self-recovering surge, the cockpit engine indications may fluctuate slightly and briefly. The flight crew may not notice the fluctuation, unless autofeather engages or an ignition light comes on. If the surge self-recovers, no crew action is necessary.

Alternatively, the engine may surge two or three times before full self-recovery. When this happens, there are likely to be cockpit engine instrumentation shifts of sufficient magnitude and duration to be noticed by the flight crew.

If the engine does not recover automatically from the surge, it may surge continually until the flight crew takes action to stop the process. The desired action is to retard the power lever until the engine recovers. The pilot should then SLOWLY re-advance the power lever. Occasionally, an engine may surge only once but still not self-recover.

When a compressor surge is not recoverable, there will be a single bang and the engine will decelerate to zero power as if the fuel had been chopped. This type of compressor surge can accompany a severe engine damage malfunction; it can also occur without any engine damage at all.

The actual cause for the compressor surge is often complex and may or may not result from severe engine damage. Rarely does a single compressor surge CAUSE severe engine damage, but sustained surging will eventually over-heat the turbine, as too much fuel is being provided for the volume of air that is reaching the combustor. Compressor blades may also be damaged and fail as a result of repeated violent surges; this will rapidly result in an engine that cannot run at any power setting.

Flameout/shutdown

A flameout is a condition where the combustion process within the burner has stopped. A flameout will be accompanied by a drop in ITT, in torque, in engine core speed and in engine pressure ratio. The first symptom noticed by the pilot may be a yaw as the propeller becomes a source of drag, or autofeather of the propeller accompanied by a drop in propeller RPM. The engine ignition light may come on.

The flameout may result from the engine running out of fuel, severe inclement weather, a volcanic ash encounter, a control system malfunction, or unstable engine operation (such as a compressor stall). Momentary flameout may be perceived as a short-term power fluctuation accompanied by an ignition light. No pilot action is necessary provided the engine recovers within a few seconds.

A flameout at takeoff power is unusual – only about 10% of flameouts occur at takeoff power.

Fire

“Engine fire” almost always refers to a fire outside the engine but within the nacelle. A fire in the vicinity of the engine should be annunciated to the flight crew by a firewarning in the flight deck. It is unlikely that the flight crew will see, hear, or immediately smell an engine fire. Sometimes, flight crews are advised of a fire by communication with the control tower.

It is important to know that, given a fire in the nacelle, there is adequate time to make the first priority "fly the airplane" before attending to the fire. It has been shown that, even in incidences of fire indication immediately after takeoff, there is adequate time to continue climb to a safe altitude before attending to the engine. There may be economic damage to the nacelle, but the first priority of the flight crew should be to ensure the airplane continues in safe flight.

Flight crews should regard any firewarning as a fire, even if the indication goes away when the power lever is retarded to idle. The indication might be the result of pneumatic leaks of hot air into the nacelle. The fire indication could also be from a fire that is small or sheltered from the detector so that the fire is not apparent at low power. Fire indications may also result from faulty detection systems. Some fire detectors allow identification of a false indication (testing the fire loops), which may avoid the need for an IFSD. There have been times when the control tower has mistakenly reported the flames associated with a compressor surge as an engine "fire."

In the event of a firewarning annunciation, the flight crew must refer to the checklists and procedures specific to the airplane being flown. In general, once the decision is made that a fire exists and the aircraft is stabilized, engine shutdown should be immediately accomplished by feathering the propeller and shutting off fuel to the engine, both at the engine fuel control shutoff and the wing/pylon spar valve. All bleed air, electrical, and hydraulics from the affected engine will be disconnected or isolated from the airplane systems to prevent any fire from spreading to or contaminating associated airplane systems. This is accomplished by one common engine "fire handle." The fire handle controls the fire by greatly reducing the fuel available for combustion, by reducing the availability of pressurized air to any sump fire, by temporarily denying air to the fire through the discharge of fire extinguishant, and by removing sources of re-ignition, such as live electrical wiring and hot casings. It should be noted that some of these control measures may be less effective if the fire is the result of severe damage – the fire may take slightly longer to extinguish under these circumstances. In the event of a shutdown after an in-flight engine fire, there should be no attempt to restart the engine unless it is critical for continued safe flight, as the fire is likely to re-ignite once the engine is restarted.

Tailpipe fire

One of the most alarming events for passengers, flight attendants, ground personnel and even air traffic control (ATC) to witness is a tailpipe fire. Fuel may puddle in the turbine casings and exhaust during start-up or shutdown, and then ignite. This can result in a highly-visible jet of flame out the back of the engine. Passengers have initiated emergency evacuations in these instances, leading to serious injuries.

Some airplanes have overtemperature detectors installed around the tailpipe; others may give no indication of an anomaly to the flight crew until the cabin crew or control tower draws attention to the problem. They are likely to describe it as an “engine fire,” but a tailpipe fire will NOT result in an engine firewarning on the flight deck. There may be a warning such as “TAIL P HOT.”

If notified of an engine fire without any fire indications in the cockpit, the flight crew should accomplish the tailpipe fire procedure. It will include motoring the engine to help extinguish the flames, while most other engine abnormal procedures will not. The normal engine fire procedure is not effective in controlling a tailpipe fire.

Since the fire is burning within the turbine casing and exhaust nozzle, pulling the fire handle to discharge extinguishant to the space between casings and cowls will be ineffective. Pulling the fire handle may also make it impossible to dry motor the engine, which is the quickest way of extinguishing most tailpipe fires.

Birdstrike/Foreign Object Damage (FOD)

Airplane engines encounter birds most often in the vicinity of airports, either during takeoff or during landing. Encounters with birds occur during both daytime and nighttime flights. By far, most bird encounters do not affect the safe outcome of a flight. In more than half of the bird ingestions into engines, the flight crew is not even aware that the ingestion took place. When a large bird is involved, the flight crew may notice a thud, bang or vibration. If the bird enters the engine core, there may be a smell of burnt flesh in the flight deck or passenger cabin from the bleed air.

Birdstrikes can damage an engine or propeller. Foreign Object Damage (FOD) from other sources, such as tire fragments, runway debris or animals, may also be encountered, with similar results.

Bird ingestion can also result in an engine surge. The surge may have any of the characteristics listed in the surge section.

Severe engine damage

Severe engine damage may be difficult to define. From the viewpoint of the flight crew, severe engine damage is mechanical damage to the engine that looks "bad and ugly." To the manufacturers of the engine and the airplane, severe engine damage may involve symptoms as obvious as large holes in the engine cases and nacelle or as subtle as the non-response of the engine to power lever movement. It is important for flight crews to know that severe engine damage may be accompanied by symptoms such as firewarning (from leaked hot air) or engine surge because the compressor stages that hold back the pressure may not be intact or in working order due to the engine damage. In this case, the symptoms of severe engine damage will be the same as a surge without recovery. There will be a loud noise. EPR will drop quickly; torque, NP, NG and fuel flow will drop. (If the propeller is governing, propeller RPM may not change.) ITT may rise momentarily. There will be a loss of power to the airplane as a result of the severe engine damage. It is not important to initially distinguish between a non-recoverable surge with or without severe engine damage, or between a fire and a firewarning with severe engine damage. The priority of the flight crew still remains "fly the airplane." Once the airplane is stabilized, the flight crew can diagnose the situation.

Engine seizure

Engine seizure describes a situation where the engine rotors stop turning in flight, perhaps very suddenly. The static and rotating parts lock up against each other, bringing the rotor to a halt. In practice, this is only likely to occur at low rotor RPM after an engine shutdown.

Seizure cannot occur without very severe engine damage, to the point where the vanes and blades of the compressor and turbine are mostly destroyed. This is not an instantaneous process – there is a great deal of inertia in the turning rotor compared to the energy needed to break interlocking rotating and static components.

Once the airplane has landed, and the rotor is no longer being driven by ram air, seizure is frequently observed after severe damage.

Symptoms of engine seizure in flight may include vibration, zero rotor speed, mild airplane yaw, and, possibly, unusual noises.

Engine separation

Engine separation is an extremely rare event. It will be accompanied by loss of all primary and secondary parameters for the affected engine, noises, and airplane yaw (especially at high power settings). Separation is most likely to occur during takeoff/climb-out or the landing roll. Airplane handling may be affected. It is important to use the fire handle to close the spar valve and prevent a massive overboard fuel leak; refer to the airplane flight or operations manual for specific procedures.

Fuel system problems

Fuel leaks

Major leaks in the fuel system are a concern to the flight crew because they may result in engine fire, or, eventually, in fuel exhaustion. A very large leak can produce engine flameout.

Engine instruments will only indicate a leak if it is downstream of the fuel flowmeter. A leak between the tanks and the fuel flowmeter can only be recognized by comparing fuel usage between engines, by comparing actual usage to planned usage, or by visual inspection for fuel flowing out of the pylon or cowlings. Eventually, the leak may result in tank imbalance.

In the event of a major leak, the crew should consider whether the leak needs to be isolated to prevent fuel exhaustion.

It should be noted that the likelihood of fire resulting from such a leak is greater at low altitude or when the airplane is stationary; even if no fire is observed in flight, it is advisable for emergency services to be available upon landing.

Inability to shutdown engine

If the engine fuel shut-off valve malfunctions, it may not be possible to shut the engine down by the normal procedure, since the engine continues to run after the fuel switch is moved to the cutoff position. Closing the spar valve by pulling the fire handle will ensure that the engine shuts down as soon as it has used up the fuel in the line from the spar valve to the fuel pump inlet. This may take a couple of minutes.

Fuel filter clogging

Fuel filter clogging can result from the failure of one of the fuel tank boost pumps (the pump generates debris which is swept downstream to the fuel filter), from severe contamination of the fuel tanks during maintenance (scraps of rag, sealant, etc., that are swept downstream to the fuel filter), or, more seriously, from gross contamination of the fuel. Fuel filter clogging will usually be seen at high-power settings, when the fuel flow through the filter (and the sensed pressure drop across the filter) is greatest. If multiple fuel-filter bypass indications are seen, the fuel may be heavily contaminated with water, rust, algae, etc. Once the filters bypass, and the contaminant goes straight into the engine fuel system, the engine fuel control may no longer operate as intended. There is potential for multiple-engine flameout. The Airplane Flight or Operating Manual provides the necessary guidance.

Oil system problems

The engine oil system has a relatively large number of indicated parameters required by the regulations (pressure, temperature, quantity, filter clogging). Many of the sensors used are subject to giving false indications, especially on earlier engine models. Multiple abnormal system indications confirm a genuine failure; a single abnormal indication may or may not be a valid indication of failure.

There is considerable variation between failure progressions in the oil system, so the symptoms given below may vary from case to case.

Oil system problems may appear at any flight phase, and generally progress gradually. They may eventually lead to severe engine damage if the engine is not shut down.

Oil leaks

Leaks will produce a sustained reduction in oil quantity, down to zero (though there will still be some usable oil in the system at this point). Once the oil is completely exhausted, oil pressure will drop to zero, followed by the low oil pressure light. There have been cases where maintenance error caused leaks on multiple engines; it is, therefore, advisable to monitor oil quantity carefully on the good engines as well. Rapid change in the oil quantity after power lever movement may not indicate a leak – it may be due to oil “gulping” or “hiding” as more oil flows into the sumps.

Bearing failures

Bearing failures will be accompanied by an increase in oil temperature and indicated vibration. If a chip detector light is installed, it may come on. Audible noises and filter clog messages may follow; if the failure progresses to severe engine damage, it may be accompanied by low oil quantity and pressure indications.

Oil pump failures

Oil pump failure will be accompanied by low indicated oil pressure and a low oil pressure light, or by an oil filter clog message. For propellers that use engine oil pressure for actuation, the propeller will pitchlock or move to feather.

Oil system contamination

Contamination of the oil system – by carbon deposits, cotton waste, improper fluids, etc. – will generally lead to an oil filter clog indication or an impending bypass indication. This indication may disappear if thrust is reduced, since the oil flow and pressure differential across the filter will also drop.

No power lever response

A “no power lever response” type of malfunction is more subtle than the other malfunctions previously discussed; so subtle that it can be completely overlooked, with potentially serious consequences to the airplane.

If an engine slowly loses power – or if, when the power lever is moved, the engine does not respond – the airplane will experience asymmetric thrust. This may be partly concealed by the autopilot’s efforts to maintain the required flight condition.

As is the case with flameout, if no external visual references are available, such as when flying over the ocean at night or in IMC, asymmetric thrust may persist for some time without the flight crew recognizing or correcting it. In several cases, this has led to airplane upset, which was not always recoverable. As stated, this condition is subtle and not easy to detect.

Symptoms may include:

- Unexplained airplane attitude changes.
- Significant differences between primary parameters from one engine to the next.

If asymmetric thrust is suspected, the first response must be to make the appropriate trim or rudder input. Disconnecting the autopilot without first performing the appropriate control input or trim may result in a rapid roll maneuver. Feathering the propeller, if it is has not auto-feathered, may also be appropriate.

No starter cutout

Generally, this condition exists when the start selector remains in the start position or the engine start valve is open when commanded closed. Since the starter is intended only to operate at low speeds for a few minutes at a time, the starter may fail completely (burst) and cause further engine damage if the starter does not cut out.

Vibration

Vibration is a symptom of a wide variety of engine conditions, ranging from very benign to serious. The following are some causes of tactile or indicated vibration:

- Propeller unbalance at assembly
- Blade icing
- Birdstrike/FOD
- Bearing failure
- Blade distortion or failure

It is not easy to identify the cause of the vibration in the absence of other unusual indications. Although the vibration from some failures may feel very severe on the flight deck, it will not damage the airplane. There is no need to take action based on vibration indication alone, but it can be very valuable in confirming a problem identified by other means.

Engine vibration may be caused by propeller unbalance (ice buildup, blade material loss due to ingested material, or blade distortion due to foreign object damage) or by an internal engine failure. Reference to other engine parameters will help to establish whether a failure exists.

WRAP-UP

Many failures have similar symptoms and it may not be practicable to diagnose the nature of the engine problem from flight deck instrumentation. However, it is not necessary to understand exactly what is wrong with the engine – selecting the “wrong” checklist may cause some further economic damage to the engine, but, provided action is taken with the correct engine, and airplane control is kept as the first priority, the airplane will still be safe.