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VERSION	EFFECTIVE DATE	DESCRIPTION OF REVISION(S)
001	2016.01	Module creation and release.
002	2016.08	Format Updates
003	2017.11	Content updates and subject clarification.
004	2019.01	Fine tuned Submodule content sequence based on Appendix-A. Updated layout and styling.
004.1	2022.06	Inclusion of Measurement Standards for clarification, page iv. Minor appearance and format updates.
004.2	2023.04	Minor appearance and format updates.
005	2024.09	Regulatory update for EASA 2023-989 compliance.
005.1	2026.06	Pages 21.1 and 21.2 - Clarified procedures in the event of a ground operation engine fire.

Submodule

21

Engine Monitoring and Ground Operation

SUBMODULE KNOWLEDGE DESCRIPTIONS		LEVEL
		B1
15.21	**Engine Monitoring and Ground Operation** — Procedures for starting and ground run-up; — Interpretation of engine power output and parameters; — Trend (including oil analysis, vibration and borescope) monitoring; — Inspection of engine and components to criteria, tolerances and data specified by the engine manufacturer; — Compressor washing/cleaning; — Foreign object damage (FOD).	3

15.21 ENGINE MONITORING AND GROUND OPERATION

PROCEDURES FOR STARTING AND GROUND RUN-UP

TURBINE ENGINE OPERATION

The engine operating procedures presented here apply generally to turbofan, turboprop, turboshaft, and auxiliary power units (APU). The procedures, pressures, temperatures, and rpm that follow are intended primarily to serve as a guide. It should be understood that they do not have general application. The manufacturer's operating instructions should be consulted before attempting to start and operate any turbine engine.

A turbofan engine has only one power control lever. Adjusting the power lever, (throttle lever), sets up a thrust condition for which the fuel control meters fuel to the engine. Turbofan engines equipped with thrust reversers go into reverse thrust with the throttle pulled all the way back to idle, and then by using a separate reverse thrust lever that extends out from the front of the throttles. Turboprop engines with reversing propellers go into reverse by moving the throttle below the idle position. A separate fuel shutoff lever or switch is used to shut the engine down.

Prior to start, particular attention should be paid to the engine air inlet, the visual condition and free movement of the compressor and turbine assembly, and the parking ramp area fore and aft of the aircraft. The engine is started by using an external air power source, APU, or an already operating engine. Starter types and the engine starting cycle have been discussed previously. On multi-engine aircraft, the engines are usually started by an onboard APU that supplies the air pressure for a pneumatic starter on each engine. Air bled from the APU is used as a source of power for starting the engines. During the start, it is necessary to monitor the tachometer, the oil pressure, and the exhaust gas temperature. The normal starting sequence is:

1. Rotate the compressor with the starter.
2. Turn the ignition on.
3. Open the engine fuel valve, either by moving the throttle to idle or by moving a fuel shutoff lever or turning a switch.

Adherence to the procedure prescribed for a particular engine is necessary as a safety measure and to avoid a hot or hung start. A successful start is noted first by a rise in exhaust gas temperature. If the engine does not light up, meaning that fuel starts to burn inside of the engine within a prescribed period of time, or if the exhaust gas starting temperature limit is exceeded, a hot start, the starting procedure should be aborted. Hot starts are not common, but when they do occur, they can usually be stopped in time to avoid excessive temperature by observing the exhaust gas temperature constantly during the start. When necessary, the engine is cleared of trapped fuel or gases by continuing to rotate the compressor with the starter, but with the ignition and fuel turned off. If the engine did not light off during start after the allotted time, about 10 seconds although this time varies from engine to engine, the fuel must be shut off as the engine is being filled with unburned fuel. A hung start is when the engine lights off, but the engine will not accelerate to idle rpm.

GROUND OPERATION ENGINE FIRE

An engine fire can develop on the ground either while the engine is being started or during normal ground operations after it is started. Normal ground operations would include procedures like running the engine for test and evaluation or taxiing the airplane. An internal fire not contained within the engine combustion chamber can occur during engine starting, and even after the engine is started if an event known as a compressor stall occurs. An external engine fire, located in the space between the engine's cases and the engine cowling, can also occur if a fuel, engine oil or hydraulic fluid leak occurs.

If an uncontained fire occurs inside the engine during starting, the procedure to follow is:

1. Move the fuel shutoff lever to the OFF position to shut down the engine.
2. Leave the engine starter engaged so airflow through the engine will push the fire out the tailpipe.
3. If the uncontained fire inside the engine persists, shut off the starter, let the engine coast to a halt, and then discharge a CO_2 fire extinguisher into the engine inlet.
4. If burning fuel pushed out the tailpipe causes a fire on the ground that can be extinguished using a CO_2 fire extinguisher.

If an engine fire develops externally inside the engine cowling, the fire detection system for the airplane will sense this and turn on the fire warning light on the flight deck. The procedure to follow in this case is:

1. Move the fuel shutoff lever to the Off position to shut down the engine.
2. If the engine starter is engaged, turn off the starter so the engine will coast to a halt.
3. If the fire warning light goes out, power down the flight deck and determine the cause of the fire.
4. If the fire warning light does NOT go out, the fire T-handle on the flight deck should be pulled out in order to shut off all fluids to the engine.
5. If the fire still persists, the T-handle should be rotated to discharge the fire extinguishing agent.

ENGINE CHECKS

Checking turbofan engines for proper operation consists primarily of simply reading the engine instruments and then comparing the observed values with those known to be correct for any given engine operating condition. After the engine has started, idle rpm has been attained, and the instrument readings have stabilized, the engine should be checked for satisfactory operation at idling speed. The oil pressure indicator, tachometer, and the exhaust gas temperature readings should be compared with the allowable ranges.

CHECKING TAKEOFF THRUST

Takeoff thrust is checked by adjusting the throttle to obtain a single, predicted reading on the engine pressure ratio (EPR) indicator in the aircraft, or by observing the proper N1 fan speed on the RPM percent indicator. Some engines use an EPR gauge as the primary thrust indicator, while others use fan speed as the primary indication.

The value for engine pressure ratio, which represents takeoff thrust for the prevailing ambient atmospheric conditions, is calculated from a takeoff thrust setting curve or, on newer aircraft, is a function of the onboard computer. The curve has been computed for static conditions. [**Figure 21-1**] Therefore, for all precise thrust checking, the aircraft should be stationary, and stable engine operation should be established. If it is needed for calculating thrust during an engine trim check, turbine discharge pressure (Pt7) is also shown on these curves. Appropriate manuals should be consulted for the charts for a specific make and model engine.

The engine pressure ratio computed from the thrust setting curve represents thrust or a lower thrust called part power thrust used for testing. The aircraft throttle is advanced to obtain this predicted reading on the engine pressure ratio indicator, or the part power stop is engaged in the aircraft. If an engine develops the predicted thrust and if all the other engine instruments are reading within their proper ranges, engine operation is considered satisfactory. Full authority digital engine controls (FADEC) (computer controls) also have means of checking the engine with the results displayed on the flight deck.

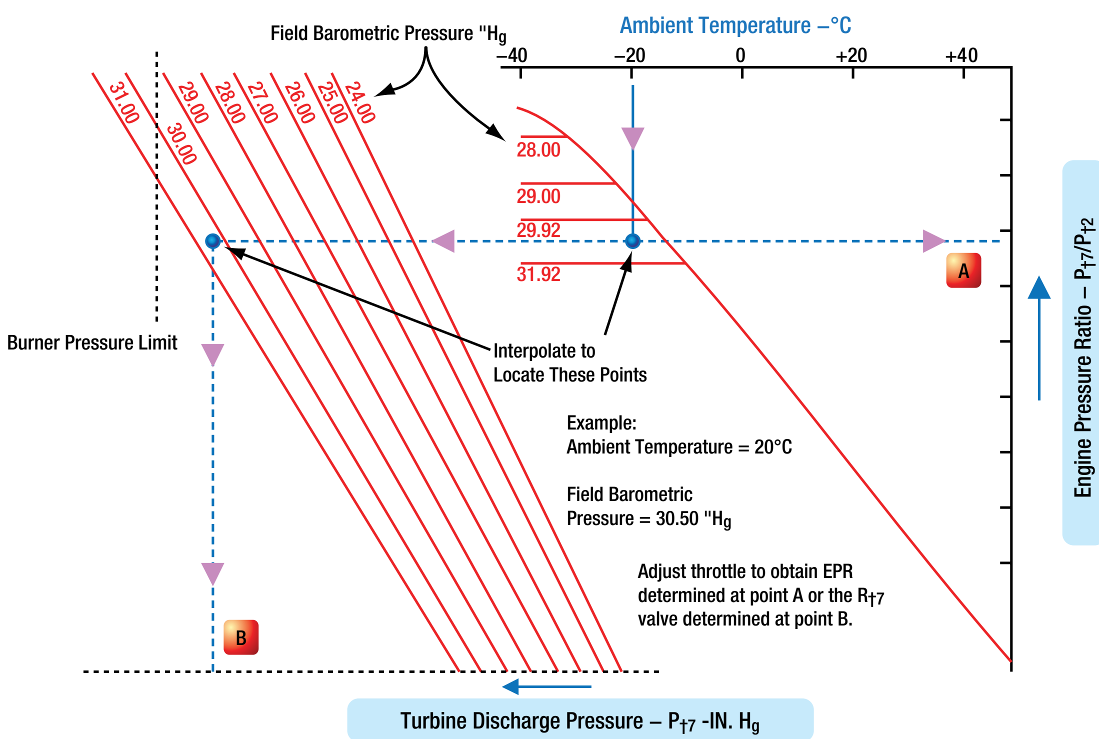

Figure 21-1. Typical takeoff thrust setting curve for static conditions.