Designation: F3064/F3064M – 24

Standard Specification for Aircraft Powerplant Control, Operation, and Indication[1]

This standard is issued under the fixed designation F3064/F3064M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers minimum requirements for the control, indication, and operational characteristics of propulsion systems. It was developed based on propulsion system installed on aeroplanes, but may be applicable to other applications as well.

1.2 The applicant for a design approval must seek the individual guidance to their respective CAA body concerning the use of this standard as part of a certification plan. For information on which CAA regulatory bodies have accepted this standard (in whole or in part) as a means of compliance to their Aeroplane Airworthiness regulations (Hereinafter referred to as "the Rules"), refer to ASTM F44 webpage (www.ASTM.org/COMITTEE/F44.htm) which includes CAA website links. Annex A1 maps the Means of Compliance described in this specification to EASA CS-23, amendment 5, or later, and FAA 14 CFR Part 23, amendment 64, or later.

1.3 *Units*—The values stated are SI units followed by imperial units in brackets. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F3060 Terminology for Aircraft

F3061/F3061M Specification for Systems and Equipment in Aircraft

F3062/F3062M Specification for Aircraft Powerplant Installation

F3063/F3063M Specification for Aircraft Fuel Storage and Delivery

F3116/F3116M Specification for Design Loads and Conditions

F3117/F3117M Specification for Crew Interface in Aircraft

F3233/F3233M Specification for Flight and Navigation Instrumentation in Aircraft

F3367 Practice for Simplified Methods for Addressing High-Intensity Radiated Fields (HIRF) and Indirect Effects of Lightning on Aircraft

F3432 Practice for Powerplant Instruments

2.2 *EASA Standard:*[3]

CS-23 Certification Specifications for Normal-Category Aeroplanes

2.3 *FAA Documents:*[4]

14 CFR Part 23 Airworthiness Standards: Normal Category Airplanes

AC 33.28-1 Compliance Criteria For 14 CFR §33.28, Aircraft Engines, Electrical And Electronic Engine Control Systems

AC 33.28-2 Guidance Material For 14 CFR §33.28, Reciprocating Engines, Electrical And Electronic Engine Control Systems

AC 33.28-3 Guidance Material For 14 CFR §33.28, Engine Control Systems

3. Terminology

3.1 The following are a selection of relevant terms. See Terminology F3060 for more definitions and abbreviations.

[1] This specification is under the jurisdiction of ASTM Committee F44 on General Aviation Aircraft and is the direct responsibility of Subcommittee F44.40 on Powerplant.

Current edition approved March 1, 2024. Published March 2024. Originally approved in 2015. Last previous edition approved in 2021 as F3064/F3064M–21. DOI: 10.1520/F3064_F3064M-24.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from European Union Aviation Safety Agency (EASA), Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany, https://www.easa.europa.eu.

[4] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.

3.2 *Definitions:*

3.2.1 *automatic power reserve (APR) system, n*—the automatic system used only during takeoff, including all devices both mechanical and electrical that sense engine failure, transmit signals, actuate fuel/energy controls or power levers on operating engines, including power sources, to achieve the scheduled power increase and furnish cockpit information on system operation.

3.2.2 *critical time interval, n*—period starting at V_1 minus one second and ending at the intersection of the engine and APR failure flight path line with the minimum performance all engine flight path line. The engine and APR failure flight path line intersects the one-engine-inoperative flight path line at 122 m [400 ft] above the takeoff surface. The engine and APR failure flight path is based on the airplane's performance and must have a positive gradient of at least 0.5 % at 122 m [400 ft] above the takeoff surface. See Fig. 1.

3.2.3 *loss-of-thrust-control/loss of power control (LOTC/LOPC), n*—loss of capability to modulate and maintain thrust or power between flight idle and a specified percent of maximum rated power or thrust, at all operating conditions.

3.2.4 *powerplant instrument, n*—the visual presentation of a powerplant (Terminology F3060) parameter, a powerplant installation (Terminology F3060) parameter, a parameter required by the engine manufacturer, or fuel/energy system parameter necessary to provide performance and condition information for the airplane operation.

3.2.5 *selected takeoff power, n*—the power obtained from each initial power setting approved for takeoff.

4. Powerplant Controls

4.1 *General Requirements:*

4.1.1 Powerplant controls must be located and arranged per Specification F3117/F3117M.

4.1.2 Each flexible control must be shown to be suitable for the particular application.

4.1.3 Each control must be able to maintain any necessary position without:

4.1.3.1 Constant attention by flight crew members; or

4.1.3.2 Tendency to creep due to control loads or vibration.

4.1.4 Each control must be able to withstand operating loads without failure or excessive deflection that will impede or negatively affect intended operation.

4.1.5 For turbine engine powered airplanes, no single failure or malfunction, or probable combination thereof, in any powerplant control system may cause the failure of any powerplant function necessary for safety.

4.1.6 The portion of each powerplant control located in the engine compartment that is required to be operated in the event of fire must be at least fire resistant.

4.1.7 Powerplant valve controls located in the cockpit must have:

4.1.7.1 For manual valves, positive stops or in the case of fuel valves suitable index provisions, in the open and closed position; and

4.1.7.2 For power-assisted valves, a means to indicate to the flight crew when the valve is in the fully open or fully closed position; or is moving between the fully open and fully closed position.

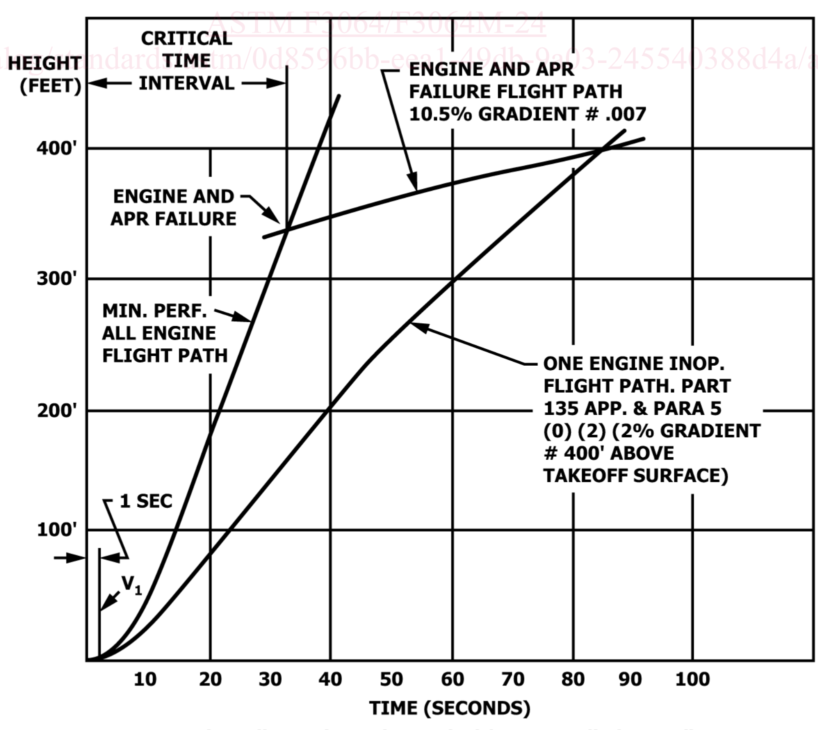

FIG. 1 Critical Time Interval

4.2 *Ignition Switches:*

4.2.1 Aeroplanes with combustion based engines that utilize spark ignition must have independent ignition switches that must control and shut off each ignition circuit on each engine.

4.3 *Power, Thrust, Supercharger Controls:*

4.3.1 There must be a separate power or thrust control for each engine and a separate control for each supercharger that requires a control.

4.3.2 Each power, thrust, or supercharger control must give a positive and immediate responsive means of controlling its engine or supercharger.

4.3.3 The power, thrust, or supercharger controls for each engine or supercharger must be independent of those for every other engine or supercharger.

4.3.4 For each fluid injection (other than fuel) system and its controls not provided and approved as part of the engine, the applicant must show that the flow of the injection fluid is adequately controlled.

4.3.5 If a power, thrust, or a fuel control (other than a mixture control) incorporates a fuel shutoff feature, the control must have a means to prevent the inadvertent movement of the control into the shutoff position. This means must:

4.3.5.1 Have a positive lock or stop at the idle position; and

4.3.5.2 Require a separate and distinct operation to place the control in the shutoff position.

4.3.6 Each power or thrust control must be designed so that if a control separates at the engine fuel/energy metering device, the airplane is capable of continued safe flight and landing.

4.4 *Fuel/Energy Mixture Controls:*

4.4.1 If there are mixture controls, each engine must have a separate control.

4.4.2 Aeroplanes with a manual engine mixture control must be designed so that, if the control separates at the engine fuel/energy metering device, the airplane is capable of continued safe flight and landing.

4.5 *Propeller Speed Pitch and Feathering Controls:*

4.5.1 If there are propeller speed or pitch controls, they must:

4.5.1.1 Allow separate control of each propeller.

4.5.1.2 Allow ready synchronization of all propellers on multiengine airplanes.

4.5.2 If there are propeller feathering controls installed:

4.5.2.1 It must be possible to feather each propeller separately.

4.5.2.2 Each control must have a means to prevent inadvertent operation.

4.6 *Reverse Thrust and Propeller Pitch Settings:*

4.6.1 For turbine engine installations, each control for reverse thrust and for propeller pitch settings below the flight regime must have means to prevent its inadvertent operation that includes:

4.6.1.1 A positive lock or stop at the flight idle position.

4.6.1.2 A separate and distinct operation by the crew to displace the control from the flight regime (forward thrust regime for turbojet powered airplanes).

4.7 *Carburetor Air Temperature Controls:*

4.7.1 For carburetor equipped airplanes there must be a separate carburetor air temperature control for each engine.

4.8 *Auxiliary Power Unit Controls:*

4.8.1 Means must be provided on the flight deck for the starting, stopping, monitoring, and emergency shutdown of each installed auxiliary power unit.

4.9 *Powered Operated Valves:*

4.9.1 Power Operated valves must have a means to:

4.9.1.1 Indicate to the flight crew when the valve has reached the selected position; and

4.9.1.2 Not move from the selected position under vibration conditions likely to exist at the valve location.

4.10 *Fuel Valves and Energy Controls:*

4.10.1 There must be a means to allow appropriate flight crew members to rapidly shut off, in flight, the supply of fuel/energy to each engine individually.

4.10.2 No shutoff valve may be on the engine side of any firewall. In addition, there must be means to:

4.10.2.1 Guard against inadvertent operation of each shutoff valve; and

4.10.2.2 Allow appropriate flight crew members to reopen each valve rapidly after it has been closed.

4.10.3 Each valve and fuel system control must be supported so that loads resulting from its operation or from accelerated flight conditions are not transmitted to the lines connected to the valve.

4.10.4 Each valve and fuel system control must be installed so that gravity and vibration will not affect the selected position.

4.10.5 Each shutoff valve handle and its connections to the valve mechanism must have design features that minimize the possibility of incorrect installation.

4.10.6 Fuel tank selector valves must:

4.10.6.1 Have a separate and distinct action to place the selector in the "OFF" position; and

4.10.6.2 Have the tank selector positions located in such a manner that it is impossible for the selector to pass through the "OFF" position when changing from one tank to another.

4.11 *Electronic Engine Control (EECS):*

4.11.1 For electronic engine control system (EECS) (Terminology F3060) installations, no single failure or malfunction or foreseeable combinations of failures of EECS components shall have an effect on the installed system that causes the probability of loss-of-thrust-control/loss of power control (LOTC/LOPC) to exceed that which was required in the engine certification.

NOTE 1—The term "foreseeable" in this context is defined as those failures or failure combinations which could occur a few times when considering the entire operational life of all airplanes of one type. A qualitative assessment is required for each EECS installation considering all foreseeable events that may not have been considered in the part 33 EECS safety assessment which may invalidate the approved LOTC/LOPC rates (reference AC33.28-1 (paragraph 6-3(a)(2), AC33.28-2 tables 5-1 and 5-2, and AC33.28-3 paragraph 62(d)).

4.11.2 Electronic engine control system installations shall be evaluated for environmental and atmospheric conditions, including lightning and HIRF (Terminology F3060) as follows:

4.11.2.1 The EECS lightning and HIRF effects that result in LOTC/LOPC shall be analyzed utilizing the threat levels associated with a catastrophic failure.

4.11.2.2 The EECS as installed in the aircraft shall be shown to meet the requirements of Specification F3061/F3061M for Indirect Effects of Lightning and High Intensity Radiated Fields (HIRF) protection.

4.11.2.3 If Practice F3367 is used, single reciprocating engine installations shall meet the requirements defined for airplane assessment level I or higher for HIRF and airplane assessment level II or higher for indirect effects of lightning.

4.11.3 The components of the installation shall be constructed, arranged, and installed to ensure their continued safe operation between normal inspections or overhauls.

4.11.4 Functions incorporated into any electronic engine control system that make it part of any equipment, systems, or installation whose functions are beyond that of basic engine control, and which could also introduce system failures and malfunctions, are not exempt from normal category airplane system safety certification requirements and shall be shown to meet normal category airplane certification levels of safety as derived from those requirements. Engine certification data, if applicable, is acceptable to support compliance with any normal category airplane certification requirements.

NOTE 2—If engine certification data is to be used to support substantiation of compliance with normal category airplane certification requirements, then the normal category airplane certification applicant should be able to provide this data to support their showing of compliance.

5. Powerplant Operational Characteristics and Installation

5.1 *Powerplant Operating Characteristics:*

5.1.1 Turbine engine powerplant operating characteristics must:

5.1.1.1 Be investigated in flight to determine that no adverse characteristics (such as stall, surge, or flameout) are present, to a hazardous degree, during normal and emergency operations within the range of operating limitations of the airplane and of the engine.

5.1.2 Forced air induction engine operating characteristics must be investigated in flight to assure that no adverse characteristics, as a result of an inadvertent overboost, surge, flooding, or vapor lock, are present during normal or emergency operation of the engine(s) throughout the range of operating limitations of both airplane and engine.

5.2 *Negative Acceleration:*

5.2.1 No hazardous malfunction of an engine, an auxiliary power unit approved for use in flight, or any component or system associated with the powerplant or auxiliary power unit may occur when the airplane is operated at the negative accelerations within the flight envelopes prescribed in Specification F3116/F3116M. This must be shown for the greatest value and duration of the acceleration expected in service.

5.3 *Cooling—General:*

5.3.1 The powerplant and auxiliary power unit cooling provisions must:

5.3.1.1 Maintain the temperatures of powerplant components and engine fluids, and auxiliary power unit components and fluids within the limits established for those components and fluids under the most adverse ground, and water conditions; and

5.3.1.2 Demonstrate flight operations to the maximum altitude and maximum ambient atmospheric temperature conditions for which approval is requested, including after normal engine and auxiliary power unit shutdown.

5.4 *Cooling Tests—Correction Factors:*

5.4.1 *General*—Compliance with 5.3 must be shown on the basis of tests, for which the following apply:

5.4.1.1 If the tests are conducted under ambient atmospheric temperature conditions deviating from the maximum for which approval is requested, the recorded powerplant temperatures must be corrected under 5.4.3 and 5.4.4, unless a more rational correction method is applicable.

5.4.1.2 No corrected temperature determined under 5.4.1.1 of this standard may exceed established limits.

5.4.1.3 The fuel used during the cooling tests must be of the minimum grade approved for the engine.

5.4.1.4 For turbocharged engines, each turbocharger must be operated through that part of the climb profile for which operation with the turbocharger is requested.

5.4.1.5 For a reciprocating engine, the mixture settings must be the leanest recommended for climb.

5.4.2 *Maximum Ambient Atmospheric Temperature*—A maximum ambient atmospheric temperature corresponding to sea level conditions of at least 38 °C [100 °F] must be established. The assumed temperature lapse rate is 2 °C per 305 meter [3.6 °F per thousand feet] of altitude above sea level until a temperature of –56.5 °C [–69.7 °F] is reached, above which altitude the temperature is considered constant at –56.5 °C [–69.7 °F].

5.4.2.1 For winterization installations, the applicant may select a maximum ambient atmospheric temperature corresponding to sea level conditions of less than 38 °C [100 °F].

5.4.3 *Correction Factor (Except for Cylinder Barrels)*—Temperatures of engine fluids and powerplant components (except cylinder barrels) for which temperature limits are established, must be corrected by adding to them the difference between the maximum ambient atmospheric temperature for the relevant altitude for which approval has been requested and the temperature of the ambient air at the time of the first occurrence of the maximum fluid or component temperature recorded during the cooling test.

5.4.4 *Correction Factor for Cylinder Barrel Temperatures*—Cylinder barrel temperatures must be corrected by adding to them 0.7 times the difference between the maximum ambient atmospheric temperature for the relevant altitude for which approval has been requested and the temperature of the ambient air at the time of the first occurrence of the maximum cylinder barrel temperature recorded during the cooling test.

5.5 *Cooling Test Procedures for Turbine Engine Powered Airplanes:*

5.5.1 Compliance with 5.3 must be shown for all phases of operation. The airplane must be flown in the configurations, at the speeds, and following the procedures recommended in the

Airplane Flight Manual for the relevant stage of flight, that correspond to the applicable performance requirements that are critical to cooling.

5.5.2 Temperatures must be stabilized under the conditions from which entry is made into each stage of flight being investigated, unless the entry condition normally is not one during which component and engine fluid temperatures would stabilize (in which case, operation through the full entry condition must be conducted before entry into the stage of flight being investigated in order to allow temperatures to reach their natural levels at the time of entry).

5.5.3 The takeoff cooling test must be preceded by a period during which the powerplant component and engine fluid temperatures are stabilized with the engines at ground idle.

5.5.4 Cooling tests for each stage of flight must be continued until:

5.5.4.1 The component and engine fluid temperatures stabilize;

5.5.4.2 The stage of flight is completed; or

5.5.4.3 An operating limitation is reached.

5.6 *Cooling Test Procedures for Reciprocating Engine Powered Airplanes:*

5.6.1 Compliance with 5.3 must be shown for the climb (or, for multiengine airplanes with negative one-engine-inoperative rates of climb, the descent) stage of flight.

5.6.2 The airplane must be flown in the configurations, at the speeds and following the procedures recommended in the Airplane Flight Manual that correspond to the applicable performance requirements that are critical to cooling.

5.7 *Engine Starting and Stopping:*

5.7.1 *Starting and Stopping (Piston Engine):*

5.7.1.1 The design of the installation must be such that:

(1) Risk of fire or mechanical damage to the engine or airplane, as a result of starting the engine in any conditions in which starting is to be permitted, is reduced to a minimum.

(2) Any techniques and associated limitations for engine starting must be established and included in the Airplane Flight Manual, approved manual material, or applicable operating placards.

(3) Means must be provided for restarting any engine in flight.

(4) Means must be provided for stopping any engine in flight, after engine failure, if continued engine rotation would cause a hazard to the airplane.

5.7.2 *Starting and Stopping (Turbine Engine)*—Turbine engine installations must comply with the following:

5.7.2.1 The design of the installation must be such that risk of fire or mechanical damage to the engine or the airplane, as a result of starting the engine in any conditions in which starting is to be permitted, is reduced to a minimum. Any techniques and associated limitations must be established and included in the Airplane Flight Manual, approved manual material, or applicable operating placards.

5.7.2.2 There must be means for stopping combustion within any engine and for stopping the rotation of any engine if continued rotation would cause a hazard to the airplane.

5.7.2.3 Each component of the engine stopping system located in any fire zone must be fire resistant.

5.7.2.4 If hydraulic propeller feathering systems are used for stopping the engine, the hydraulic feathering lines or hoses must be fire resistant.

5.7.2.5 It must be possible to restart an engine in flight.

5.7.2.6 Any techniques and associated limitations must be established and included in the Airplane Flight Manual, approved manual material, or applicable operating placards.

5.7.2.7 It must be demonstrated in flight that when restarting engines following a false start, all fuel or vapor is discharged in such a way that it does not constitute a fire hazard.

5.7.3 *Starting and Stopping—Level 4 Aeroplane:*

5.7.3.1 Each component of the stopping system on the engine side of the firewall that might be exposed to fire must be at least fire resistant.

5.7.3.2 If hydraulic propeller feathering systems are used for this purpose, the feathering lines must be at least fire resistant under the operating conditions that may be expected to exist during feathering.

5.7.4 *Restart Envelope*—An altitude and airspeed envelope must be established for the airplane for inflight engine restarting and each installed engine must have a restart capability within that envelope.

5.7.5 *Restart Capability*—For turbine engine powered airplanes, if the minimum windmilling speed of the engines, following the inflight shutdown of all engines, is insufficient to provide the necessary electrical power for engine ignition, a power source independent of the engine-driven electrical power generating system must be provided to permit inflight engine ignition for restarting.

5.8 *Powerplant Limitations:*

5.8.1 *General*—The powerplant limitations prescribed in this subsection must:

5.8.1.1 Be established so that they do not exceed the corresponding limits established by the manufacturer in the case of all powerplants including those that do not have a type certificate.

5.8.1.2 Be established so that they do not exceed the corresponding limits for which certificated engines or propellers are type certificated (as applicable).

5.8.1.3 Include other powerplant limitations used in determining compliance.

5.8.2 *Takeoff Operation*—The powerplant takeoff operations must be limited by:

5.8.2.1 The maximum rotational speed (rpm);

5.8.2.2 The maximum allowable manifold pressure (for reciprocating engines);

5.8.2.3 The maximum allowable gas temperature (for turbine engines);

5.8.2.4 The time limit for the use of the power or thrust corresponding to the limitations established in 5.8.2.1 – 5.8.2.3; and

5.8.2.5 The maximum allowable cylinder head (as applicable), liquid coolant and oil temperatures.

5.8.3 *Continuous Operation*—The continuous operation must be limited by:

5.8.3.1 The maximum rotational speed;

5.8.3.2 The maximum allowable manifold pressure (for reciprocating engines);

5.8.3.3 The maximum allowable gas temperature (for turbine engines); and

5.8.3.4 The maximum allowable cylinder head, oil, and liquid coolant temperatures.

5.8.4 *Fuel Grade or Designation*—The minimum fuel grade (for reciprocating engines), or fuel designation (for turbine engines), must be established so that it is not less than that required for the operation of the engines within the limitations described in 5.8.2 and 5.8.3.

5.8.5 *Ambient Temperature*—For all Level 1 and 2 turbine powered airplanes and all Level 3 and 4 airplanes, an ambient temperature limitations (including limitations for winterization installations if applicable) must be established as the maximum ambient atmospheric temperature at which compliance with the cooling provisions in 5.3 – 5.6 is shown.

5.9 *Automatic Power Reserve (APR) Systems:*

5.9.1 If installed, an automatic power reserve (APR) system that automatically advances the power or thrust on the operating engine(s), when any engine fails during takeoff, must comply with 5.9.2 – 5.9.6.

5.9.2 With the APR system and associated systems functioning normally, all applicable requirements (except as provided in 5.9.2 – 5.9.6) must be met without requiring any action by the crew to increase power or thrust.

5.9.3 *Reliability and Performance Requirements:*

5.9.3.1 It must be shown that, during the critical time interval, an APR failure that increases or does not affect power on either engine will not create a hazard to the airplane, or it must be shown that such failures are improbable.

5.9.3.2 It must be shown that, during the critical time interval, there are no failure modes of the APR system that would result in a failure that will decrease the power on either engine or it must be shown that such failures are extremely improbable.

5.9.3.3 It must be shown that, during the critical time interval, there will be no failure of the APR system in combination with an engine failure or it must be shown that such failures are extremely improbable.

5.9.3.4 All applicable performance requirements must be met with an engine failure occurring at the most critical point during takeoff with the APR system functioning normally.

5.9.4 *Power Setting*—The selected takeoff power set on each engine at the beginning of the takeoff roll may not be less than:

5.9.4.1 The power necessary to attain, at V_1, 90 % of the maximum takeoff power approved for the airplane for the existing conditions;

5.9.4.2 That required to permit normal operation of all safety-related systems and equipment that are dependent upon engine power or power lever position; and

5.9.4.3 That shown to be free of hazardous engine response characteristics when power is advanced from the selected takeoff power level to the maximum approved takeoff power.

5.9.5 *Powerplant Controls—General:*

5.9.5.1 In addition to the requirements of subsection 4.1, no single failure or malfunction (or probable combination thereof) of the APR, including associated systems, may cause the failure of any powerplant function necessary for safety.

5.9.5.2 The APR must be designed to:

(1) Provide a means to verify to the flight crew before takeoff that the APR is in an operating condition to perform its intended function;

(2) Automatically advance power on the operating engines following an engine failure during takeoff to achieve the maximum attainable takeoff power without exceeding engine operating limits;

(3) Prevent deactivation of the APR by manual adjustment of the power levers following an engine failure;

(4) Provide a means for the flight crew to deactivate the automatic function. This means must be designed to prevent inadvertent deactivation; and

(5) Allow normal manual decrease or increase in power up to the maximum takeoff power approved for the airplane under the existing conditions through the use of power levers, as stated in 4.1.3, except as provided under 5.9.5.3.

5.9.5.3 For airplanes equipped with limiters that automatically prevent engine operating limits from being exceeded other means may be used to increase the maximum level of power controlled by the power lever in the event of an APR failure. The means must:

(1) Be located on or forward of the power levers;

(2) Be easily identified and operated under all operating conditions by a single action of any pilot with the hand that is normally used to actuate the power levers; and

(3) Must meet the applicable crew interface requirements.

5.9.6 *Powerplant Instruments*—In addition to the requirements described in 6.2, the following are required:

5.9.6.1 A means must be provided to indicate when the APR is in the armed or ready condition.

5.9.6.2 If the inherent flight characteristics of the airplane do not provide warning that an engine has failed, a warning system independent of the APR must be provided to give the pilot a clear warning of an engine failure during takeoff.

5.9.6.3 Following an engine failure at V_1 or above, there must be means for the crew to readily and quickly verify that the APR has operated satisfactorily.

6. Installation of Powerplant Instruments, Indicators and Sensors

6.1 *Powerplant Instruments Installation:*

6.1.1 *Instruments and Instrument Lines*—Each powerplant and auxiliary power unit instrument line must meet the fluid system lines and fittings requirements defined in Specification F3062/F3062M.

6.1.1.1 Each powerplant and auxiliary power unit instrument that utilizes flammable fluids must be installed and located so that the escape of fluid would not create a hazard.

6.1.2 *Fuel/Energy Quantity Indication*—There must be a means to indicate to the flight crew members the quantity of usable fuel/energy in each tank during flight. An indicator calibrated in appropriate units and clearly marked to indicate those units must be used.

6.1.2.1 Each fuel/energy quantity indicator must be calibrated to read "zero" during level flight when the quantity of fuel/energy remaining is equal to the unusable fuel/energy supply determined under Specification F3063/F3063M.