U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: **POWERPLANT GUIDE FOR CERTIFICATION OF PART 23 AIRPLANES**

Date: 9/21/99
Initiated By: ACE-100

AC No.: 23-16
Change:

1. PURPOSE. This Advisory Circular (AC) provides information and guidance concerning acceptable means, but not the only means of compliance with Title 14 of the Code of Federal Regulations (14 CFR) Part 23, Subpart E, applicable to the powerplant installation in normal, utility, acrobatic, and commuter category airplanes. This AC consolidates existing policy documents, and certain AC's that cover specific paragraphs of the regulations, into a single document. Material in this AC is neither mandatory nor regulatory in nature and does not constitute a regulation.

Wherever there is no written policy or guidance material applicable to a specific paragraph, the phrase, "No policy available as of March 11, 1996," is used. AC's approved after this date may be included as reference material only.

2. CANCELLATION. The following AC's are canceled:

a. AC 23.909-1 — Installation of Turbochargers in Small Airplanes with Reciprocating Engines, dated February 3, 1986;

b. AC 23.955-1 — Substantiating Flow Rates and Pressures in Fuel Systems of Small Airplanes, dated June 10, 1985;

c. AC 23.959-1 — Unusable Fuel Test Procedures for Small Airplanes, dated January 14, 1985;

d. AC 23.961-1 — Procedures for Conducting Fuel System Hot Weather Operation Tests, dated January 14, 1987; and

e. AC 23.1011-1 Procedures for Determining Acceptable Fuel/Oil Ratio as Required by FAR 23.1011(b), dated November 14, 1983.

3. BACKGROUND. The AC is current through Amendment 23-51, effective March 11, 1996. This material spans approximately 30 years of Federal Aviation Administration (FAA) and Civil Aviation Authority (CAA) aviation history.

4. APPLICABILITY. This material does not have any legal status and should be treated accordingly. However, to ensure standardization in the certification process, these procedures should be considered during all small airplane Type Certification (TC) and Supplemental Type Certification (STC) activities.

In all cases, the user of this AC should check the latest Amendments to the applicable Federal Aviation Regulations (FAR)/Joint Aviation Requirements (JAR) to verify that the regulations referenced in this AC have not been superseded or that additional regulations have not been added.

5. PARAGRAPHS KEYED TO PART 23. Each paragraph has the applicable Part 23 Amendment showing in the title. As Part 23 changes occur, the appropriate revisions will be made to the effected paragraphs of this AC.

6. RELATED REGULATIONS AND PUBLICATIONS.

a. Regulations: Part 23 through Amendment 23-51. While this AC specifically addresses only those regulations in Subpart E, the following additional regulations are related to the airplane powerplant:

Subpart B — Flight

§ 23.33	Propeller speed and pitch limits.
§ 23.45	Performance.
§ 23.239	Spray characteristics.

Subpart C — Structure

§ 23.307	Proof of structure.
§ 23.361	Engine torque.
§ 23.363	Side load on engine mount.

Subpart D — Design and Construction

§ 23.611	Accessibility provisions.
§ 23.771	Pilot compartment.
§ 23.777	Cockpit controls.
§ 23.779	Motion and effect of cockpit controls.
§ 23.781	Cockpit control knob shape.

§ 23.859	Combustion heater fire protection.
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Subpart F — Equipment

§ 23.1305	Powerplant instruments.
§ 23.1309	Equipment, systems, and installations.
§ 23.1311	Electronic display instrument systems.
§ 23.1321	Arrangement and visibility.
§ 23.1322	Warning, caution, and advisory lights.
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§ 23.1437	Accessories for multiengine airplanes.

Subpart G — Operating Limitations and Information

§ 23.1501	General.
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§ 23.1549	Powerplant and auxiliary power unit instruments.
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§ 23.1555	Control markings.
§ 23.1557	Miscellaneous markings and placards.
§ 23.1583	Operating limitations.
§ 23.1585	Operating procedures.

b. Advisory Circulars: Copies of current publications of the following *free* Orders and AC's listed below can be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785:

FAA Order 8100.5	Aircraft Certification Directorate Procedures
FAA Order 8110.4A	Type Certification Process
AC 20-29B	Use of Aircraft Fuel Anti-icing Additives
AC 20-32B	Carbon Monoxide (CO) Contamination in Aircraft—Detection and Prevention

AC 20-43C	Aircraft Fuel Control
AC 20-53A	Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Due to Lightning
AC 20-66	Vibration Evaluation of Aircraft Propellers
AC 20-73	Aircraft Ice Protection
AC 20-88	Guidelines on the Marking of Aircraft Powerplant Instruments (Displays)
AC 20-100	General Guidelines for Measuring Fire-Extinguishing Agent Concentrations in Powerplant Compartments
AC 20-107A	Composite Aircraft Structure
AC 20-116	Marking Aircraft Fuel Filler Openings with Color Coded Decals
AC 20-122A	Anti-misfueling Devices: Their Availability and Use
AC 20-124	Water Ingestion Testing for Turbine Powered Airplanes
AC 20-128A	Design Considerations for Minimizing Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor and Fan Blade Failures
AC 20-135	Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria
AC 20-136	Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning
AC 21-37	Primary Category Aircraft
AC 21.17-3	Type Certification of Very Light Airplanes Under FAR 21.17(b)
AC 23-2	Flammability Tests
AC 23-10	Auxiliary Fuel Systems for Reciprocating and Turbine Powered Part 23 Airplanes

AC 23-11	Type Certification of Very Light Airplanes with Powerplant and Propellers Certificated to Parts 33 and 35 of the Federal Aviation Regulations (FAR)
AC 23-14	Type Certification Basis for Conversion from Reciprocating Engine to Turbine Engine-Powered Part 23 Airplanes
AC 23-15	Small Airplane Certification Compliance Program
AC 23.1305-1	Installation of Fuel Flowmeters in Small Airplanes with Continuous-Flow, Fuel Injection, Reciprocating Engines
AC 23.1309-1C	Equipment, Systems, and Installations in Part 23 Airplanes
AC 23.1311-1A	Installation of Electronic Displays in Part 23 Airplanes
AC 23.1419-2A	Certification of Part 23 Airplanes for Flight in Icing Conditions
AC 23.1521-1B	Type Certification of Automobile Gasoline in Part 23 Airplanes with Reciprocating Engines
AC 23.1521-2 with Change 1	Type Certification of Oxygenates and Oxygenated Gasoline Fuels in Part 23 Airplanes with Reciprocating Engines
AC 25.939-1	Evaluating Turbine Engine Operating Characteristics
AC 33-2B	Aircraft Engine Type Certification Handbook
AC 33.47-1	Detonation Testing in Reciprocating Aircraft Engines
AC 33.74/92	Turbine Engine Continued Rotation and Rotor Locking
AC 35.37-1	Composite Propeller Blade Fatigue Substantiation

Copies of current publications of the following *for sale* AC's may be purchased from the Superintendent of Documents, P. O. Box 371954, Pittsburgh, PA 15250–7954. Make a check or money order payable to the Superintendent of Documents:

AC 20-88A	Guideline on the Marking of Aircraft Powerplant Instruments (Displays)
AC 23-8A with Change 1	Flight Test Guide for Certification of Part 23 Airplanes

Copies of *Transport Canada TP10141E, Design Standards for Ultra Light Aeroplanes*, may be obtained from the Federal Aviation Administration, Small Airplane Directorate, Regulations and Policy Branch (ACE-111), DOT Building―Room 301, 901 Locust, Kansas City, MO 64106–2641.

c. Certification personnel should be familiar with *FAA Order 8100.5, Aircraft Certification Directorate Procedures*, and *FAA Order 8110.4A, Type Certification Process.*

Signed

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Aircraft Certification Service

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Subpart E—Powerplant

GENERAL

23.901 Installation (Amendment 23-51)

Related Material

AC 23.1311-1A, Installation of Electronic Displays in Part 23 Airplanes.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

Related Material

AC 23-10, Auxiliary Fuel Systems for Reciprocating and Turbine Powered Part 23 Airplanes.

(c) Design the powerplant installation to provide access (cowling that is easily opened and closed) for the pilot to visually check the following:

(1) Engine oil level;

(2) For flammable fluid leaks;

(3) If applicable, the exterior condition of the turbocharger and wastegate installation;

(4) Electrical wiring;

(5) Fuel and oil lines and fittings; and, otherwise, make a cursory inspection of the engine installation; and

(6) Other items as defined by the engine or airplane manufacturer.

For additional information refer to § 23.611, Accessibility provisions.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

Related Material

AC 23.1521-2, Type Certification of Oxygenates and Oxygenated Gasoline Fuels in Part 23 Airplanes with Reciprocating Engines.

AC 20-122A, Anti-misfueling Devices: Their Availability and Use.

(f) No policy available as of March 11, 1996

Related Material

AC 20-128A, Design Considerations for Minimizing Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor and Fan Blade Failures.

23.903 Engines (Amendment 23-51)

(a) Use an engine(s) with an approved type certificate (per 14 CFR Part 33 or CAR Part 13) for normal, utility, acrobatic, and commuter category airplanes certificated under Part 23. The only possible exception is an airplane certificated under 14 CFR Part 21, § 21.17(b), as applied to airplanes originally certificated in the Primary Category, under Joint Aviation Requirements—Very Light Airplane (JAR-VLA), or Sport Plane (Transport Canada Design Standard TP10141E). For these airplanes, the engine ***may,*** but is not required to, have an approved type certificate, as the engine may be approved as part of the airframe.

For more information on the use of certificated engines and propellers under JAR-VLA airplanes refer to AC 23-11, Type Certification of Very Light Airplanes with Powerplants and Propellers Certificated to Parts 33 and 35 of the Federal Aviation Regulations (FAR). For more information on the use of non-certificated engines for these airplanes refer to AC 21.17-3, Type Certification of Very Light Airplanes under FAR 21.17(b), and AC 21-37, Primary Category Aircraft.

(b) Design the airplane to minimize hazards to the airplane in the event of a turbine engine rotor failure. Design the airplane to continue safe flight and landing in the event of a maximum energy rotor burst (typically the energy level associated with a one-third sector of the engine rotor at the critical rotating speed) or any other uncontained turbine engine failure (i.e., fan blade).

Information on engine case burn through is contained in the related material.

Related Material

AC 20-128A, Design Considerations for Minimizing Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor and Fan Blade Failures.

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

(c) No policy available as of March 11, 1996.

Related Material

AC 23.1419-2A, Certification of Part 23 Airplanes for Flight in Icing Conditions.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

Related Material

AC 23-2, Flammability Tests.

AC 33.74/92, Turbine Engine Continued Rotation and Rotor Locking.

(f) The requirement to define the in-flight restart envelope applies to all normal, utility, acrobatic, and commuter category airplanes. A full complement of tests to define the in-flight restart envelope may or not be necessary. For example, normally aspirated reciprocating engine in-flight restart procedures typically only specify the airspeed to restart the engine. In this case, the "restart envelope" is the entire flight envelope for the selected airspeed. On the other hand, defining a turbine engine restart envelope typically requires data from a comprehensive altitude/airspeed envelope test program.

(1) Airplanes powered by reciprocating engines.

The amount of in-flight restart envelope testing is dependent upon the particular design features of the engine installation. Comprehensive in-flight restart envelope testing is not usually necessary for single-engine airplanes powered by conventional reciprocating engines. The service experience of these airplanes with typical reciprocating engine installations is that a reliable in-flight engine restart can be made, provided the airplane is equipped with an adequate engine starting system. Thus in-flight restart envelope testing has not been necessary provided a mechanically sound engine can be restarted under typical power-off flight conditions.

However, if the engine installation contains new or non-conventional design features, more extensive in-flight restart envelope testing may be necessary. This is particularly the case when the flight conditions impact the ability to restart the engine in flight. For example, consider the effects of new or unusual engine designs or operating cycles, propeller feathering systems, engine control systems, fuels or fuel system arrangements, engine starting systems, etc. Any in-flight restart envelope limitations and/or starting procedures should be defined in the appropriate areas of the Airplane Flight Manual (AFM).

As with conventional designs, extensive in-flight restart envelope testing may not be required provided the applicant can substantiate this position with respect to the new or non-conventional design features. Flight tests are generally the most appropriate means to develop this substantiating data.

(2) Airplanes powered by turbine engines.

Turbine engine starting is sensitive to small differences in flight conditions, primarily pressure altitude, speed, temperature, and attitude. Therefore, it is necessary to test the engine restart envelope to ensure that turboprop or turbofan engines can be reliably restarted in flight. These flight conditions and the associated starting procedures (windmill, starter assisted, or otherwise) should be defined in the appropriate areas of the Airplane Flight Manual (AFM).

Related Material

AC 23.1521-1B, Type Certification of Automobile Gasoline in Part 23 Airplanes with Reciprocating Engines.

AC 23.1521-2 with Change 1, Type Certification of Oxygenates and Oxygenated Gasoline Fuels in Part 23 Airplanes with Reciprocating Engines.

(g) No policy available as of March 11, 1996.

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

23.904 Automatic power reserve system (Amendment 23-43)

No policy available as of March 11, 1996.

23.905 Propellers (Amendment 23-43)

Related Material:

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

(a) No policy available as of March 11, 1996.

(b) Evaluate the maximum propeller power and shaft rotational speed for each airplane installation throughout its normal operational envelope. The installed limits may be below the certificated propeller power and rotational speed limits (listed on the propeller type certificate data sheet) that are typically based on static ground testing performed prior to flight test.

The applicant also needs to consider possible transient exceedances of the maximum engine power and propeller shaft rotational speed.

14 CFR Part 23, § 23.33, contains additional requirements pertaining to the installed propeller speed and pitch limits.

(c) No policy available as of March 11, 1996.

(d) The propeller Type Certificate Data Sheet (TCDS) identifies operationally compatible components of the propeller blade pitch control system that may or may not be included in the propeller type design. If the propeller blade pitch control system components are included in the propeller type design (verify this with the propeller manufacturer or the FAA office controlling the propeller type design), the components have demonstrated compliance with 14 CFR Part 35, § 35.42, Blade pitch control system component test.

The propeller manufacturer may not have tested components that are not included in the propeller type design per § 35.42. For components that have not been previously tested, demonstrate compliance with § 35.42 either by testing or by similarity to prior approved components.

(e) Propeller type certification does not include any type of foreign object damage requirements, unless accomplished with special conditions or special tests.

Related Material:

AC 23.1419-2A, Certification of Part 23 Airplanes for Flight in Icing Conditions.

(f) No policy available as of March 11, 1996.

(g) Propeller type certification does not include any type of engine exhaust gas requirements, unless accomplished with special conditions or special tests.

(h) No policy available as of March 11, 1996.

23.907 Propeller vibration (Amendment 23-51)

For acceptable means of compliance refer to AC 20-66, Vibration Evaluation of Aircraft Propellers.

General Discussion:

The following applies to all propellers except conventional fixed-pitch wood propellers:

(1) The most important part of approving a propeller installation is to demonstrate that the propeller vibration stresses do not exceed safe levels. It is often beneficial to use approved propeller type design data (contact the propeller manufacturer) to approve a propeller for use on an aircraft.

(2) Perform a flight-vibration stress survey. The stress survey should identify any operational and maintenance limitations to note in the airplane Instructions for Continued Airworthiness and/or Airplane Flight Manual (AFM). These limitations may also need to be incorporated into the propeller airworthiness limitations section. According to § 23.1521, operational limitations are to be made available to the crew by the use of appropriate placards and powerplant instrument markings (i.e., red and yellow arcs).

Related Material

AC 20-88A, Guidelines on the Marking of Aircraft Powerplant Instruments (Displays).

(3) In pusher propeller installations, perform the vibration survey under the same caustic and high temperature environmental conditions identified in § 23.905(g).

(4) Additionally, the Maintenance Manual should require regular calibration of the tachometer to ensure that the limits are not exceeded.

Related Material:

AC 20-66, Vibration Evaluation of Aircraft Propellers.

AC 35.37-1, Composite Propeller Blade Fatigue Substantiation.

23.909 Turbocharger systems (Amendment 23-43)

GENERAL:

Section 23.909 contains requirements for approval of turbochargers in Part 23 airplanes and refers to design standards contained in Part 23 and 14 CFR Part 33, Airworthiness Standards: Aircraft Engines.

The applicable turbocharged engine-installation requirements are as follows:

(1) Apply §§ 23.909(a) through 23.909(e) to a turbocharger system (or portions of the system) that is ***not approved*** as part of the engine under Part 33.

(2) If the turbocharger system (or portions of the system) ***is approved*** as part of the engine under Part 33; then §§ 23.909(b) through 23.909(e) apply.

Related Material:

AC 23-8A, Flight Test Guide for Certification of Part 23 Airplanes.

AC 23.1521-2 with Change 1, Type Certification of Oxygenates and Oxygenated Gasoline Fuels in Part 23 Airplanes with Reciprocating Engines.

AC 33-2B, Aircraft Engine Type Certification Handbook.

AC 33.47-1, Detonation Testing in Reciprocating Aircraft Engines.

DEFINITIONS:

Turbocharger System: Includes the following:

(1) The turbocharger;

(2) All components necessary to control the turbocharger and the associated engine/installation connections;

(3) All ducting, heat exchangers, and other plumbing between the turbocharger to the engine intake and exhaust interface points;

(4) All plumbing and control devices between the turbocharger and the aircraft; and

(5) Mounting provisions for these components.

Turbocharger: Any engine exhaust gas-driven compressor that is a component of one or more of the following systems:

(1) Turbonormalized Engine: Turbocharger used to maintain sea level manifold pressure to a critical altitude.

(2) Turbosupercharged Engine: Turbocharger used to provide and maintain a manifold pressure greater than sea level pressure to a critical altitude.

(3) Cabin Pressurization Systems: Turbocharger used to pressurize air for airframe services.

Intercooler: A device installed in the engine air induction system that lowers the intake air charge temperature. The intercooler can be approved either as part of the engine or the engine installation.

DISCUSSION:

Characteristics of Turbocharger

When you add a turbocharger to an otherwise normally aspirated engine, there will be affects on engine reliability and power output. Consider the following items:

a. Durability

A turbocharged engine will have different endurance and reliability characteristics than the non-turbocharged engine.

A turbocharged engine will have different overhaul characteristics and intervals than the non-turbocharged engine.

A turbocharged engine will have different detonation characteristics than the non-turbocharged engine. Detonation margin is affected by the following:

(1) Induction air temperature and pressure;

(2) Exhaust back pressure;

(3) Ignition timing;

(4) Fuel grade and flow;

(5) Carburetor or injector metering characteristics;

(6) Compression ratio;

(7) Cooling; and

(8) Exhaust gas temperature.

A turbocharger has high speed rotating components similar to a turbine engine. Consider the effects of low-cycle fatigue on turbocharger rotor integrity and durability.

b. Control Systems

A turbocharged engine requires additional systems necessary to control the turbocharger, such as the wastegate and wastegate controller.

Determine the effects of cold oil on the operating characteristics of the turbocharger wastegate and any oil-operated flow control devices.

c. Containment

A turbocharger has high speed rotating components similar to a turbine engine. Consider the possibility of damage from turbine or compressor rotor failure.

d. Intercooler and Induction System

A turbocharged engine has higher induction air temperatures at altitude because of the increased compression required to maintain engine manifold pressure. Turbocharger speed and compressor discharge temperature increase up to critical altitude.

NOTE. Critical altitude is defined as pressure altitude on an International Standard Atmospheric (ISA) day.

e. Engine Power, Cooling, and Operational Limits

It is difficult to thermodynamically match a turbocharger to an engine by analysis alone. A combination of test data and analysis is required for performance predictions and correction factors.

Turbocharger lubrication systems may be self-contained or require oil from an external source.

If pressurized engine oil is used, the additional requirement might exceed the capacity of the engine oil pump. Heat rejected by the turbocharger to the oil might exceed the engine oil system cooling provisions. Air entrained in turbocharger scavenge oil might overload the engine breather or scavenge systems. Additional engine-driven oil scavenge capacity might be required; otherwise, use a separate turbocharger lubricating system and ensure its adequacy.

Reliability of Turbocharger

When you add a turbocharger to an engine installation, there will be affects on the reliability of the installation. Consider the following items:

a. Durability

Expect higher temperatures with a turbocharged engine's induction system due to the heat generated in compressing induction air, as well as positive internal pressure instead of suction by the engine.

Expect higher rates of oil consumption, contamination, and deterioration due to the more severe operating environment. These items may shorten oil change intervals.

Expect higher flow rates of hot exhaust gas with a turbocharged engine's exhaust system, which will increase the temperature of the metal and raise internal pressure. Consequently, the durability of the exhaust system components is important. Increased or mandatory inspections of the exhaust system components may be necessary.

Both the engine and propeller vibration characteristics of the turbocharged engine installation might be altered by changes in horsepower and by changes in horsepower-to-altitude relations. Readdress the propeller vibration compatibility per § 23.907 or determine if propeller recertification is necessary.

b. Control Systems

A turbocharged engine requires additional systems necessary to control the turbocharger such as the wastegate and wastegate controller.

c. Containment

A turbocharger has high-speed rotating components similar to a turbine engine. Consider the possibility of damage from turbine or compressor rotor failure.

d. Intercooler and Induction System

Consider how adding an intercooler to the installation affects engine operating characteristics and adequacy of mounting provisions. Airflow through the intercooler should not discharge on any portion of the airplane where damage might occur—pay particular attention to windshields.

Turbochargers on engines with carburetors produce combustible mixtures (at elevated pressure and temperature) in portions of the induction system. Induction system leaks should be minimized.

Consider the relation of the turbocharger to the point of fuel introduction into the induction system. For turbocharged engines with carburetors, a combustible mixture at elevated pressure and temperature exists in portions of the induction system and should require special precautions. Also, consider that engine backfire combined with combustible mixtures in the induction system might produce fire in the system.

e. Engine Power, Cooling, Operational Limits and Procedures

The peak temperature for a turbocharged engine normally occurs at the sea level power output condition at a specified altitude. Cooling air is less effective at altitude due to its lower density.

As a general rule, design the engine cooling capacity for the sea level power output, then check the flight envelope cooling capacity at various altitudes. The applicant should investigate enough of the operating envelope to ensure that engine cooling is adequate. The simplest means to determine compliance is by performing a cooling climb test.

Acceptable fuel system vapor lock characteristics should be demonstrated under all desired operating conditions.

If the turbocharger is used for cabin pressurization, consider possible contamination of cabin air.

Diaphragm-type fuel pumps might be inadequate to supply fuel to the turbocharged engine under all operating conditions. These conditions would be determined by test. It might become necessary to add a fuel boost pump or make other changes to the pumping system to ensure freedom from vapor lock.

Consider the in-flight restart characteristics of the turbocharged engine.

Operating procedures to minimize potential hazards relating to fire and/or loss of engine power due to a turbocharger failure should be specified in the "Emergency Procedures" section of the Pilot Operating Handbook (POH) and/or the Airplane Flight Manual (AFM). This requirement would not apply to the following:

(1) Existing turbocharged aircraft without FAA-approved AFM's or POH's;

(2) Aircraft that were only required to have placards; or

(3) To aircraft that have unapproved POH's or owners manuals.

However, new TC/STC applicants certificating or modifying any aircraft for a turbocharger installation should consider this requirement.

ACCEPTABLE MEANS OF COMPLIANCE:

There are four methods to approve a turbocharger installation on an engine:

(1) As part of the engine type certificate;

(2) By means of an engine supplemental type certificate;

(3) By complying with § 23.909, which allows approval of the turbocharger installation as part of the airplane type certificate; or

(4) By complying with § 23.909, which allows approval of the turbocharger installation as part of the airplane supplemental type certificate.

The following requirements apply to the turbocharged engine or turbocharged engine installation as applicable:

Paragraph (a) requirements apply when the turbocharger system (or portions of the system) ***is not*** approved as part of the engine under Part 33.

(a) (1) Turbocharger and Turbocharged Engine Durability

Endurance tests or investigations should be conducted to meet the reliability standards established by the 150-hour endurance test under § 33.49, Endurance test, for the engine/turbocharger combination. Establish the service life of the components as required by § 33.7, Engine ratings and operating limitations.

Any component of the engine and turbocharger installation not substantiated by endurance testing as capable of operating in all normally anticipated flight and atmospheric conditions should be subjected to additional tests, or investigations to substantiate this capability as required by § 33.53, Engine component tests.

Affects of low-cycle fatigue on turbocharger rotor integrity and durability: A rotor without prior service history should be subjected to a 1,000-cycle start-stop test under the most adverse operating conditions to provide a basis for establishing initial service life.

The applicant should provide instructions for the installation, operation, service, maintenance, repair, and overhaul of the turbocharger and related items as required by § 33.4, Instructions for continued airworthiness, and § 33.5, Instruction manual for installing and operating the engine. Particular attention should be given to component life limits for both the engine and turbocharger.

The exhaust system and supports should be capable of withstanding all vibration and inertia loads at the higher temperatures and pressures to which they are subjected by the turbocharger installation as required by § 23.1123, Exhaust system. Tests or investigations, as necessary, should be conducted to substantiate that the exhaust system meets the standards of airworthiness established by the basic engine 150-hour endurance test as required by § 33.49.

Turbocharger mounts and supporting structure should withstand all vibration and inertia loads to which they are subjected in operation as required by § 23.307, Proof of structure.

(a) (2) Turbocharger Effect on Engine

Conduct calibration tests and investigations to establish the sea level and altitude power characteristics of the engine and turbocharger combination.

Conduct flight tests to demonstrate that the engine operates throughout its anticipated operating range without exceeding detonation limits at limit temperatures and fuel flow, using the minimum-grade fuel. If necessary, establish the minimum fuel flow required for proper operation. Also, consider the limitations specified in the installer's instructions and as required by § 33.47, Detonation test.

Turbocharger and engine mount provisions should have sufficient strength to withstand loads arising from the conditions prescribed in § 33.23, Engine mounting attachments and structure.

NOTE. Paragraph (b) through (e) requirements apply in all cases (independent of the method and means of turbocharger approval).

(b) Control Systems

Determine the effects of cold oil on the operating characteristics of the turbocharger wastegate and any oil-operated flow control devices.

Design turbocharger control devices so that any probable failure does not result in engine or turbocharger limits being exceeded, which should preclude damage to the turbocharger compressor or turbine.

(c) Turbocharger Rotor Containment

If the turbocharger case alone has not demonstrated compliance with § 23.909(c), then the installer may provide additional containment shielding to preclude damage due to rotor failure.

No additional containment shielding is required for turbochargers approved with the engine provided:

(1) Containment has been demonstrated as required by § 33.19, Durability, and § 33.27, Turbine, compressor, fan, and turbosupercharger rotors; and

(2) The containment testing was performed at operating conditions appropriate to the airplane and its engine installation.

(d)(1) Intercooler and Induction System

Demonstrate the strength of the intercooler and mounting provisions as required by § 33.23.

Evaluate the intercooler installation for adequacy of:

(1) The intercooler and mounting provisions;

(2) Vibration response;

(3) Engine cooling;

(4) Additional instrumentation required for the intercooler to ensure that the engine ratings are not exceeded; and

(5) Any cowling or airframe protrusions located in front of the firewall for fire resistance.

Demonstrate that the induction system can withstand pressure differentials (positive and negative) and temperature levels resulting from the turbocharger under the most critical operating conditions expected.

If a filter is installed in the induction system, provide an alternate air source.

Determine the effect of turbocharger installation on ice accretion characteristics of the induction system per § 33.35(b). The induction system should meet the requirements of § 23.1091 and incorporate means to prevent and eliminate ice accumulation within the engine and turbocharger induction system, as required by § 23.1093. Associated heat rise requirements should also be evaluated.

(d)(2) No policy available as of March 11, 1996.

(d)(3) No policy available as of March 11, 1996.

(e) Power, Cooling, and Operational Limits

(e)(1) Power (Performance)

For airplanes required to comply with the performance requirements of § 23.45, Amendment 23-21, establish the actual calibrated power available at all altitudes. If performance information is required per § 23.45, Amendment 23-50, determine the actual engine power at altitude.

Investigate each engine installation at all operating points to ensure engine power output at the specified manifold pressure.

On intercooled installations, evaluate the effects the intercooler has on the engine approved limits. For example, increased engine horsepower output at the same manifold pressure and engine speed would require a method of limiting engine horsepower.

The Maintenance Manual should identify any turbocharger control system calibration checks required to ensure that the engine is maintaining the approved power output. This is especially important on installations with automatic turbocharger control systems.

(e)(2) Cooling

If turbocharger lubrication is provided by the engine oil system, the capacity of that system should be adequate to serve the engine and turbocharger under the most adverse combination of oil temperature and bearing clearances.

External lines and fittings containing flammable fluids as part of the turbocharger installation should comply with §§ 23.1017 and 23.863.

If the turbocharger oil system is self-contained, the capacity should be adequate to provide lubrication and cooling under the most adverse conditions of turbocharger oil temperature and bearing clearance.

Powerplant cooling provisions should be capable of maintaining the temperature of all powerplant components, parts, and fluids at or below the maximum established safe values under all ground and flight operating conditions as required by § 23.1047.

All portions of the engine exhaust system and turbocharger should be isolated from lines or components carrying flammable fluids, the accessory section, and primary structure by firewalls and shrouds, or by adequate separation as required by § 23.1121. Where required, adequate cooling air should be provided so that there is no adverse change in service life or failure rate of adjacent components.

Any ducting that bypasses the firewall and/or cowling should be fireproof.

(e)(3) Operating Limits

Define all operating limitations or instructions in the AFM and revise placards as required.

Demonstrate, using an engine conforming to type design data, that the approved power is not exceeded at any altitude.

Demonstrate through test that engine and turbocharger limits are not exceeded under any intended operating condition. In particular, establish that the turbocharger is operating within its speed and turbine inlet temperature limits.

Establish turbocharger oil temperature and pressure limits per § 33.39, Lubrication system.

Specify temperature limits for any components requiring special cooling as required by § 33.21, Engine cooling.

Determine whether propeller blade, crankshaft, and prop shaft stresses are within acceptable limits. The applicant should readdress the propeller vibration compatibility per § 23.907. Additionally, propeller recertification may be required.

Demonstrate compliance with § 23.955 if the maximum fuel flow has increased or the operating condition where maximum fuel flow is required has changed.

(e)(4) Operating Procedures

Demonstrate compliance with § 23.939(b), which includes a demonstration that the engine installation is free from compressor surge at all operating points.

Investigate the in-flight restart characteristics of the turbocharged engine. Demonstrate engine in-flight restart procedures.

The fuel system should be free from vapor lock throughout the flight envelope as required by § 23.961.

Because additional moisture might be introduced into the engine crankcase, demonstrate that the engine crankcase breather is adequately protected from ice blockage.

If the turbocharger provides airplane cabin pressurization, a failure of the installation should not contaminate the cabin air. Refer to § 23.831 for cabin Carbon Monoxide (CO) contamination levels and § 23.1121(a) for design requirements to prevent engine exhaust leaks that would allow CO to enter into the cabin area.

Evaluate the propeller-engine-airplane vibration characteristics at altitude to provide continued compliance with § 23.907. Additionally, demonstrate that the engine crankshaft torsion characteristics are within the original engine certificated limits or other safe operational limits.

If the turbocharger installation can affect the windshield defogging system, demonstrate continued compliance with § 23.773(b).

23.925 Propeller clearance (Amendment 23-51)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

23.929 Engine installation ice protection (Amendment 23-51)

This section applies when the applicant has requested certification with the ice protection provisions of § 23.1419.

Ice protection is the responsibility of the airplane manufacturer. Propeller type certification does not include any type of propeller ice protection requirements, unless accomplished with special conditions or special tests. In most instances, the propeller ice protection components are not included in the propeller type design.

Since the ice protection equipment is normally mounted on the propeller, include the propeller manufacturer in the process of assuring that the installation or failure of ice protection equipment will not harm the propeller. For example, an electrical short on a deicing boot could burn a hole in a composite blade or locally change the heat treatment of an aluminum blade. The resulting damage could make the propeller un-airworthy.

Related Material

AC 20-73, Aircraft Ice Protection.

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

AC 23-1419-2A, Certification of Part 23 Airplanes for Flight in Icing Conditions.

23.933 Reversing systems (Amendment 23-51)

(a) No policy available as of March 11, 1996.

(b) The requirements of 14 CFR Part 35, § 35.21, also apply to components of the propeller reversing system. If the reversing system components are included in the propeller type design (this can be verified with the propeller manufacturer or the FAA office controlling the propeller type design), the components have demonstrated compliance with § 35.21.

Components that are not included in the propeller type design may or may not have demonstrated compliance with § 35.21.

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

23.934 Turbojet and turbofan engine thrust reverser systems tests (Amendment 23-43)

No policy available as of March 11, 1996.

Related requirements are contained in 14 CFR Part 23, § 23.1155.

23.937 Turbopropeller-drag limiting systems (Amendment 23-43)

(a) A failure probability analysis may be used to show compliance with this paragraph. Show that the probability of an accident occurring because of any failure of a propeller drag limiting system (either automatic or manual) is extremely improbable.

Related Material

AC 23.1309-1C, Equipment, Systems, and Installations in Part 23 Airplanes.

(b) No policy available as of March 11, 1996.

23.939 Powerplant operating characteristics (Amendment 23-42)

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

AC 25.939-1, Evaluating Turbine Engine Operating Characteristics.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

23.943 Negative acceleration (Amendment 23-43)

No policy available as of March 11, 1996.

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

FUEL SYSTEM

23.951 Fuel System General (Amendment 23-43)

Related Material

AC 23-10, Auxiliary Fuel Systems for Reciprocating and Turbine Powered Part 23 Airplanes.

AC 23.1521-2 with Change 1, Type Certification of Oxygenates and Oxygenated Gasoline Fuels in Part 23 Airplanes with Reciprocating Engines.

(a) No policy available as of March 11, 1996.

(b) Section 23.951(b) allows fuel (for the purpose of direct engine feed) to be drawn from more than one tank at a time provided:

(1) There are means to prevent introducing air into the fuel system; and

(2) The pilot has a means to draw fuel from a single tank.

Fuel systems that supply engine fuel from more than one tank at a time do not consume fuel at the same rate from both tanks. This is attributable to differences in vents, filter condition, line losses, pumps, fuel return flow, fuel consumption rates (multiengine airplanes), etc. It is probable that one tank will run out of usable fuel while there is still usable fuel on board. To prevent air being drawn into the engine fuel supply line, use a method to seal the fuel tank outlets whenever the tank is out of usable fuel.

Substantiation tests are required for systems that draw fuel from more than one tank demonstrating that air is not drawn into the fuel system.

A series of fuel tanks can be interconnected to function as a single tank. For example, two left-handed wing tanks using gravity to feed from one to the other with interconnected vent lines function as a single tank provided that fuel is drawn from only one location. For the purposes of this discussion, these tanks may be treated as a single tank.

Interconnecting the vent lines on two independent tanks (i.e., left-hand and right-hand wing tanks feeding to a common fuel selector valve) does not cause the tanks to function as a single tank. As above, this configuration may allow air into the fuel system when either independent tank has consumed its usable fuel, unless there is a means to prevent the introduction of air.

(Many in-service airplanes were certified under the Civil Air Regulations (CAR). For background, CAR § 3.430, which preceded § 23.951(b), required the fuel system arrangement to "permit any one fuel pump to draw fuel from only one tank at a time." In the past, this has sometimes been interpreted (incorrectly) as "a fuel pump may only draw fuel from one tank at a time." The CAR regulation is actually more permissive than § 23.951(b) as it did not address the possibility of introducing air into the fuel system.)

(c) The fuel icing requirements of § 23.951(c) may be satisfied by using the anti-icing additives as specified in AC 20-29B, Use of Aircraft Fuel Anti-icing Additives.

(d) No policy available as of March 11, 1996.

23.953 Fuel system independence (Amendment 23-43)

Related Material

AC 23-10, Auxiliary Fuel Systems for Reciprocating and Turbine Powered Part 23 Airplanes.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

23.954 Fuel system lightning protection (Amendment 23-7)

Related Material

AC 20-53A, Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Due to Lightning.

AC 23-15, Small Airplane Certification Compliance Program.

AC 23.1521-2 with Change 1, Type Certification of Oxygenates and Oxygenated Gasoline Fuels in Part 23 Airplanes with Reciprocating Engines.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

23.955 Fuel flow (Amendment 23-51)

(a) General

This section provides standards for fuel flow in various types of Part 23 airplanes.

Demonstrate fuel-flow characteristics with the entire fuel system installed in the airplane during the airplane type certification program. A suitable mock-up of the fuel system can also be used to demonstrate fuel-flow capacity. Analysis may be used to reduce the tests required, provided the analysis has been validated through appropriate tests.

Some applicants may modify their airplanes in such a way as to affect the original fuel system. Changes in the type of fuel used are also considered a change to the fuel system. In these cases, additional fuel-flow testing may be required to substantiate continued compliance of the fuel system with applicable regulations and engine manufacturer's requirements.

In-service fuel that has the correct physical properties and octane ratings should flow at the rate specified by regulation, and at the pressure established in compliance with 14 CFR Part 33, § 33.7, Engine ratings and operating limitations.

As stated in § 23.955(d), the test conditions and tests provided in this section are also applicable to auxiliary fuel systems and their associated fuel transfer systems.

TEST CONDITIONS:

Airplane Attitude

Flow tests should be conducted at the critical attitude for the airplane. The critical attitude may be determined with the use of an inclinometer by flying the airplane at critical weight.

Conventional tractor airplanes normally have fuel tanks aft of the carburetor or engine injector inlet. Conditions grow less favorable for fuel flow as the airplane rotates in the “nose-up” attitude. Likewise, pusher airplanes normally have the fuel tanks forward of the carburetor or engine injector inlet making conditions less favorable for fuel flow as the airplane rotates in the “nose-down” attitude.

Minimum Inlet Pressure

The engine manufacturer usually establishes the minimum and maximum fuel pressure limits necessary to obtain acceptable engine operation. These limits are on the applicable FAA Engine Type Certificate Data Sheet (TCDS).
The fuel pressure limits are shown in a number of different ways:

- minus or plus “x” pounds per square inch (psi);
- “y” psi above true vapor pressure; and
- “z” inches fuel head differential between carburetor fuel inlet fitting and float bowl chamber.

Most of these inlet pressure limits require no conversions. Some turbine engine manufacturers specify either the minimum inlet fuel pressure as “x” psi above the true vapor pressure of the fuel used with a Vapor/Liquid (V/L) ratio of zero, or the maximum V/L ratio for emergency use should not exceed a specific value. These fuel pressure limits will require an analysis of the fuel to determine true vapor pressure of the fuel with the corresponding V/L. Alternatively, a laboratory test may be conducted to determine the engine minimum fuel inlet pressure

Supercharged Engine Fuel System Inlet Pressure

This applies to engines using either a mechanical or an exhaust-driven (turbosupercharger) device to pressurize the intake air charge.

The required fuel pressure at the carburetor or injector inlet is stated on the engine TCDS and is normally referenced to the engine inlet air (manifold) pressure. The manifold pressure is an absolute pressure and is typically stated in inches of mercury (Hg). Be sure to use compatible units when calculating the (carburetor or injector) fuel pressure minimum limit.

The inlet air (or upper deck) pressure is maintained up to the critical altitude, while the fuel tank pressure decreases with increasing altitude. This results in the greatest difference between the fuel tank pressure and the inlet air pressure at the critical altitude. Therefore, conduct pressure and flow tests at conditions that account for the difference between the tank pressure at the actual test altitude and the critical altitude. The pressure and flow tests may be done in two ways:

(1) Reduce the fuel tank pressure, or

(2) Add the difference to the pressure that the engine TCDS indicates the pump is required to deliver to the carburetor or injector.

Method to Determine Minimum Inlet Fuel Pressure for Reciprocating Engines

Should the minimum carburetor or injector-inlet fuel-pressure figure not be available from the engine manufacturer, the following process may be used to determine the acceptable inlet pressure:

(1) Connect a gravity flow fuel tank that can be varied in height in relation to the carburetor inlet. Large tubing may be used to minimize the effects of fluid friction;

(2) With the airplane in the ground attitude, run the engine at full takeoff r.p.m. and manifold pressure. Consider using a propeller that will allow full takeoff r.p.m. and satisfactorily cool the engine;

(3) Start with the fuel tank high enough to permit proper operation of the engine. Vary the fuel level by lowering the tank until the first evidence of engine malfunction occurs, then measure and record the fuel head available to the engine. This measurement is to be made from the carburetor fuel inlet to the top of the fuel level in the tank;

(4) Engine malfunction may be detected by use of an exhaust gas temperature indicator, which will indicate change in the fuel-air mixture. Any change in fuel-air mixture will result in an exhaust gas temperature change and impending engine malfunction. Also, any noticeable change in engine r.p.m. or manifold pressure will indicate a change in engine horsepower; and

(5) Establish the minimum fuel pressure 10 percent above the measured fuel pressure (at the carburetor inlet) required for acceptable engine operation.

Special Considerations

If a fuel flowmeter is installed, block the flowmeter during the flow test and measure the fuel flow through the bypass per § 23.955(a)(2).

If a fuel filter with bypass provisions is installed, block the fuel filter during the flow test and measure the fuel flow through the bypass.

For engines operating on kerosene (jet) or diesel fuels, evaluate the effects of fuel density, low temperature, altitude, attitude, and water saturation.

(b) Fuel Flow Rate for Gravity Feed Systems

This method is applicable only to airplanes with reciprocating engines. Use this method if the airplane is being certificated for use without airplane supplied fuel pumps. The airplane may be equipped with *optional* auxiliary or emergency pumps provided they are installed but not used during this test.

This test demonstrates the adequacy of the engine fuel supply under the most adverse operating condition. Measure the flow directly at the carburetor inlet (for example, if a reducing nipple is used at the carburetor inlet, measure the fuel flow through the nipple).

Position the airplane on the ground with the thrust or fuselage level line at the most critical attitude for fuel flow. A bench test using the pertinent fuel system components located at relative elevations to represent actual airplane critical attitudes may be used. If the airplane is tested in the level flight attitude, determine the appropriate fuel head for the critical attitude by analysis and test and add this fuel head to the fuel system in the level flight attitude.

Reduce the fuel pressure to the minimum operating pressure for an acceptable takeoff power mixture as recommended by the carburetor and engine manufacturer. An acceptable method of simulating the minimum pressure required at the carburetor inlet is to disconnect the fuel-feed line at the carburetor and raise the end of the line above the carburetor a distance equal to that of the required minimum operating pressure in inches of fuel.

Compensate for the differential pressure, (calculated as shown below under **Normally Aspirated, Carbureted, Reciprocating Engine Fuel System Pressure Differential**) by subtracting it from the required minimum carburetor inlet pressure. For example, if the minimum permissible fuel inlet pressure is 19-inches of fuel and a system pressure differential is 7 inches (produced between the fuel tank vent space and the carburetor float bowl airspace), then run the test with the fuel line assembly raised 12-inches above the fuel inlet fitting of the carburetor. (The pressure, in psi, can be calculated at approximately one psi for each 40-inches head of fuel.)

Alternatively, compute the sum of the head pressure associated with best rate-of-climb and carburetor inlet requirements, and demonstrate (with the fuel restricted by a valve installed at the engine-end of the system to simulate this pressure) that fuel flow is at least equal to the regulatory minimum.

Completely drain the fuel system before beginning the test. Set the system to feed from one tank only. Slowly add fuel to the tank until a steady flow is established at the inlet to the carburetor or fuel injector unit. Steady flow should be established when approximately the usable fuel supply has been added. When steady flow has been established, add an additional gallon (or the fuel quantity necessary to complete the flow test) to the tank.

Record the time in seconds for at least one gallon of fuel to flow from the feed line. The time for one gallon of fuel to flow should not be more than the figure computed from the following equations:

(1) For reciprocating engine-powered airplanes, certificated under Part 3 of the CAR or 14 CFR Part 23, at the rate of 150 percent of the actual fuel flow to the engine at maximum takeoff power:

Seconds per gallon = 14,400/(SFC)(TOHP)

Where SFC = Engine Specific Fuel Consumption (SFC) (at Takeoff Power (TOPH)) expressed in (lb./bhp/hr.)

TOHP = Engine brake horsepower (bhp) at takeoff

(2) For reciprocating engine-powered airplanes certificated under Part 04a of the CAR, at the rate of double the normal flow required for takeoff engine power:

Seconds per gallon = 10,800/(SFC)(TOHP)

NOTE. For the purpose of this discussion, engine fuel flow has been defined by the calculated term (SFC)(TOHP). If the engine manufacturer has specified a higher maximum fuel flow rate, then use that fuel flow rate in place of the calculated term. These calculations are based upon a fuel density of 6 lbs. per U.S. gallon.

NOTE. The fuel flow for airplanes powered by a turbine engine(s) under Part 23, should meet the requirements discussed under **Fuel Flow Rate for Pressure Regulated Systems** below.

Normally Aspirated, Carbureted, Reciprocating Engine Fuel System Pressure Differential

A pressure differential normally exists between the fuel tank airspace and the carburetor float bowl airspace at various climb attitudes and climb speeds. Account for this pressure differential when calculating the minimum fuel head for conducting fuel-flow tests. One way to determine the fuel system pressure differential is as follows:

- Connect a calibrated airspeed indicator between the fuel tank vent and the carburetor float bowl airspace. Connect the pitot pressure connection to the fuel tank vent airspace and the static connection to the carburetor float bowl airspace. Use a liquid trap on each side of the airspeed indicator. The carburetor float bowl should be vented to the atmosphere at the normal carburetor air passage during the test.

- With the airspeed indicator installed as described above, fly the airplane at critical weight (using the regular airspeed indicator) at the best angle-of-climb airspeed (V_Y) with the carburetor inlet air heat off, and a full rich mixture setting (if mixture is controllable). Record the airspeed indicated on the instrument connected between the fuel tank and the carburetor.

- Calculate the pressure differential (ΔH) between the fuel tank vent airspace and the carburetor float bowl using this equation:

$$\Delta H = 6.81\ (V/100)^2$$

Where ΔH = Pressure differential in inches of fuel
V = Airspeed indicator reading in miles per hour

- The ΔH obtained may be subtracted from the minimum carburetor inlet pressure specified by the engine manufacturer to determine the minimum pressure to be substantiated by the fuel flow tests. (See Figure 1 below in this AC section.)

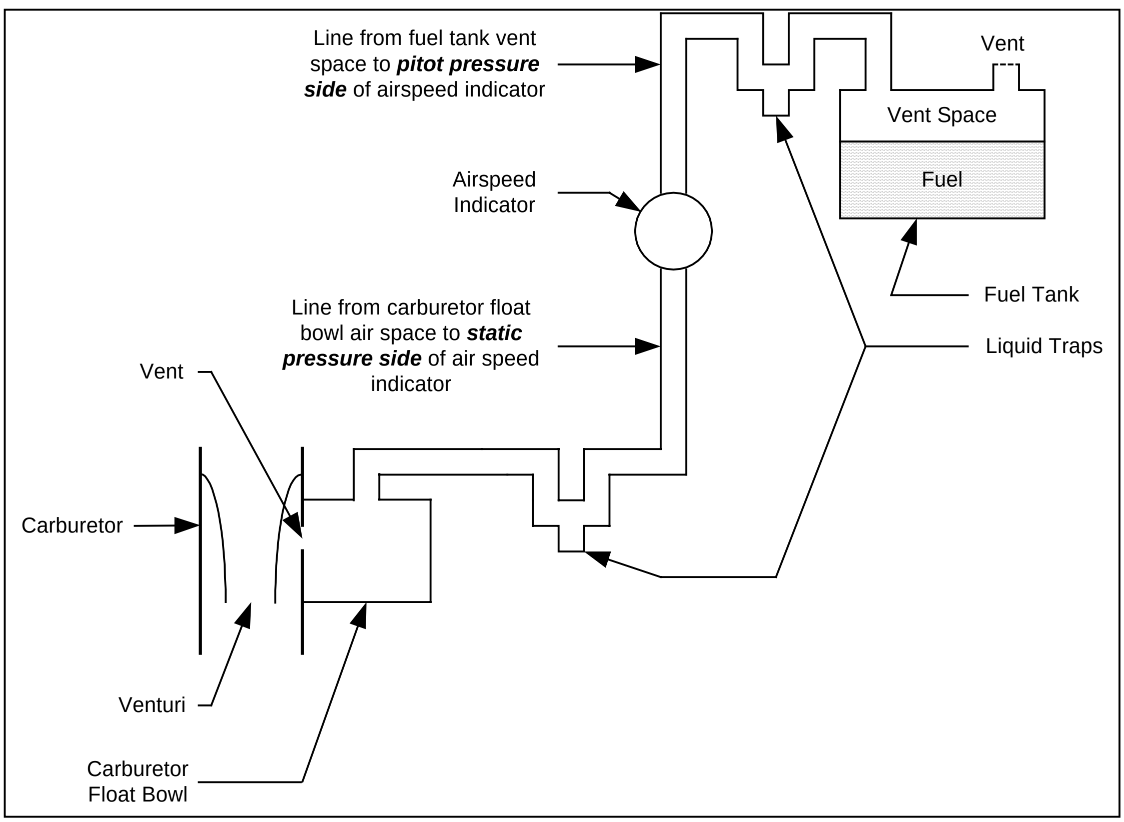


FIGURE 1

- A U-tube manometer (see Figure 2 below in this AC section) containing actual fuel or any other appropriate fluid may be used instead of the airspeed indicator to determine the pressure differential. Use of the manometer allows reading pressure differential directly in inches of fuel or the chosen fluid. If some other fluid is used, correct the differential height for the specific gravity of the test fluid. A U-tube manometer is generally commercially available or can be constructed of clear plastic or glass tubing.

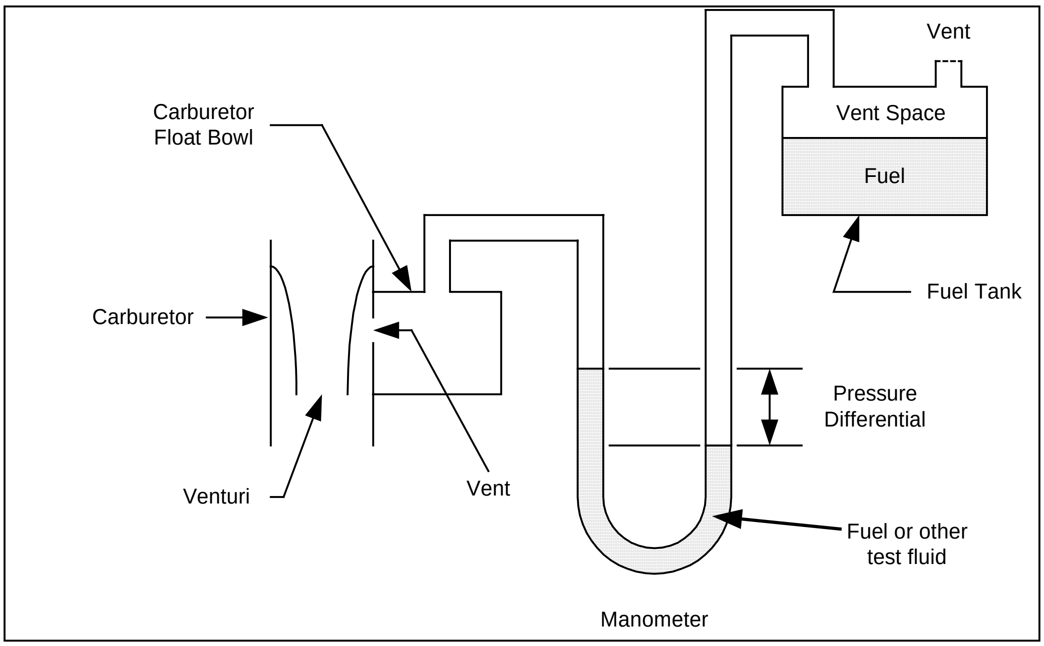


FIGURE 2

- Installation of a U-tube manometer, containing fuel, in the cabin can be very hazardous; therefore, take special precautions to prevent damage or spillage. Incorporate provisions to collect and drain any fuel spillage overboard.

(c) Pump Feed Systems

These tests are required to demonstrate that the airplane fuel system can deliver an adequate fuel supply to the engine.

Fuel Flow Rate for Pressure Regulated Systems

Conduct these fuel-flow rate tests by placing the airplane in the same attitude as outlined in the procedure for gravity-feed fuel system tests. Operate the fuel pump either driven by the engine with the pump mounted on the regular engine-fuel pump drive pad, or by a separate external power source.

If conducted with the pump mounted on the engine, use a separate source of fuel, external to the airplane, to operate the engine at takeoff r.p.m.

If an external power source is used to drive the fuel pump, conduct the test with the pump operating at the same speed as the pump operates when the engine is running at takeoff r.p.m. Mount the pump at the same height as it would be if mounted on the fuel pump pad on the engine.

In either case, measure the pump discharge flow rate using a calibrated flowmeter and correct for inlet condition if necessary.

Completely drain the fuel system before beginning the test. Set the system to feed from one tank only. Slowly add fuel to the tank until a steady flow is established at the inlet to the carburetor or fuel injector unit. Steady flow should be established when approximately the usable fuel supply has been added. When steady flow has been established, add an additional gallon of fuel to the tank. The fuel-flow tests should be made on the main fuel-pump system followed by a test on the emergency fuel-pump system with the main pump inoperative in the critical mode for fuel delivery.

For airplanes certified under Part 23 using aviation or automobile gasoline, the time for one gallon to flow should be less than or equal to the smaller of the following:

(1) At the rate of 0.9 pounds for each TOHP:

Seconds per gallon = 24,000/TOHP

(2) At the rate of 125 percent of the actual fuel flow to the engine at maximum takeoff power:

Seconds per gallon = 17,280/(SFC)(TOHP)

For airplanes using jet or diesel fuels, the time for one gallon to flow should be less than or equal to the following at each intended operating condition and maneuver:

(3) At the rate of 100 percent fuel flow:

Seconds per gallon = 24,480 (JP-5)/(SFC)(bhp or lb. thrust)
23,400 (JP-4, Jet B)/(SFC)(bhp or lb. thrust)
23,760 (JP-7)/(SFC)(bhp or lb. thrust)
24120 (JP-8, Jet A, Jet A-1)/(SFC)(bhp or lb. thrust)

NOTE. For the purpose of this discussion, engine fuel flow has been defined by the calculated term (SFC)(TOHP) or (SFC)(bhp or lb. thrust). If the engine manufacturer has specified a higher maximum fuel flow rate, then use that fuel flow rate in place of the calculated term.

NOTE. Jet fuels vary considerably in density. For example, at 60 °F:

JP-4, Jet B range is 6.27 to 6.69 lbs./U.S. gallon
JP-5 range is 6.58 to 7.05 lbs./U.S. gallon
JP-7 range is 6.50 to 6.73 lbs./U.S. gallon
JP-8, Jet A, Jet A-1 range is 6.47 to 7.01 lbs./U.S. gallon

Since the flow rates for turbine-powered airplanes are 100 percent, account for the effects of cold fuel, blocked filters, altitude, attitude, maneuvers, acceleration, etc.

For airplanes certified under Part 04a of the CAR using aviation or automobile gasoline, the time for one gallon to flow should be less than or equal to the following:

At the rate of double the normal flow required for takeoff engine power:

Seconds per gallon = 10,800/(SFC)(TOHP)

Fuel Flow Rate for Unregulated Fuel Injection Pump Systems

Some fuel injection systems utilize an integral speed-sensing pump, approved as part of the engine type design that delivers fuel at an unregulated pressure proportional to engine speed. A fuel injection system with an integral speed sensing pressure pump (refer to AC section on § 23.991) is normally capable of suction lift at the inlet to the pump; therefore, an emergency pump may not be required. Use care in selecting and operating emergency pumps with these types of systems as engine malfunction (as defined in AC section § 23.959) can also occur due to excess fuel when operating under high fuel pressure.

Conduct these fuel-flow rate tests by placing the airplane in the same attitude as outlined in the procedure for gravity-feed fuel system tests, with the following exceptions or additions:

(1) The fuel-injector system normally has an engine-driven fuel-injector pump that is approved as part of the engine. It is necessary to show that the fuel system, excluding the injector pump, complies with the applicable regulations. Therefore, any fuel pump capable of providing the flow capacity may be used to conduct the fuel-flow tests. Pressure indicators installed in the fuel lines will be necessary to determine that the system will maintain the pressure specified by the engine manufacturer.

(2) Some engine fuel injector systems have a bypass or return-flow fuel system. These systems may be evaluated by determining that the system can conduct

fuel back to the tank at the required flow rate without exceeding the back pressure established by the engine manufacturer at the bypass exit port.

(3) When conducting the fuel flow test with a separate fuel pump, the fuel flow requirements of the main fuel system should include the quantity of fuel consumed by the engine plus the quantity returned to the fuel tank.

Airplanes equipped with engine-driven integral speed-sensing pressure pumps can experience engine misfire, stall, or other engine malfunction attributable to excess fuel should the optional emergency fuel pump produce too high an output pressure. In these cases, the optional fuel pumps are not required by the regulation as emergency pumps, but are used to supply fuel pressure at the engine-driven injector pump inlet for engine starting, vapor suppression, and in some cases, maintaining engine power after an engine-driven fuel injector pump failure. These optional pumps may have a sufficiently high fuel output pressure to adversely affect engine operation when the pump is turned on with the engine-driven pump operating normally. To ensure that the optional fuel pump operates within the maximum allowed fuel pressure limit at the inlet to engine-driven injector fuel pump, an in-flight evaluation with both pumps operating, or a ground pressure check is recommended as follows:

- Block the engine-driven fuel pump outlet line and operate the airplane’s electric fuel pump under a no-flow condition, then
- Take a pressure reading to ascertain that the fuel pressure falls within the pressure limits specified for the engine at the inlet to the fuel injector, or compare the pump manufacturer's no-flow performance pressure with the injector pump's inlet limit.

Fuel System Component Changes

Changes in components such as an engine-driven fuel pump, or a wobble pump, can often be substantiated by comparative tests of the components themselves without testing the entire airplane system. For example, a replacement fuel pump should be capable of delivering at least the same flow as the original pump when operating at the same speed, suction lift, and delivery pressure.

Related Material

AC 23.1305-1, Installation of Fuel Flowmeters in Small Airplanes with Continuous-Flow, Fuel Injection, Reciprocating Engines.

(d) No policy available as of March 11, 1996.

Related Material

AC 23-10, Auxiliary Fuel Systems for Reciprocating and Turbine Powered Part 23 Airplanes.

(e) No policy available as of March 11, 1996.

Related Material

AC 23.1521-1B, Type Certification of Automobile Gasoline in Part 23 Airplanes with Reciprocating Engines.

AC 23.1521-2 with Change 1, Type Certification of Oxygenates and Oxygenated Gasoline Fuels in Part 23 Airplanes with Reciprocating Engines.

(f) No policy available as of March 11, 1996.

23.957 Flow between interconnected tanks (Amendment 23-43)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

23.959 Unusable fuel supply (Amendment 23-51)

(a) DISCUSSION.

Certain flight conditions and attitudes are critical with respect to unusable fuel quantity. Ground maneuvers (such as taxi turns and turning takeoffs) may also be critical. The applicant should first identify and then perform tests at these critical operating conditions.

DEFINITIONS:

Unusable fuel is the largest total quantity of fuel remaining in the fuel system when the first evidence of engine malfunction occurs due to fuel interruption. Engine malfunction normally occurs under the most adverse fuel feed conditions. Each intended operation and flight maneuver should be checked for each fuel tank. (See Figure 3 below in this AC section.)

$\mathbf{V_{FE}}$ is the maximum airplane flap extended speed.

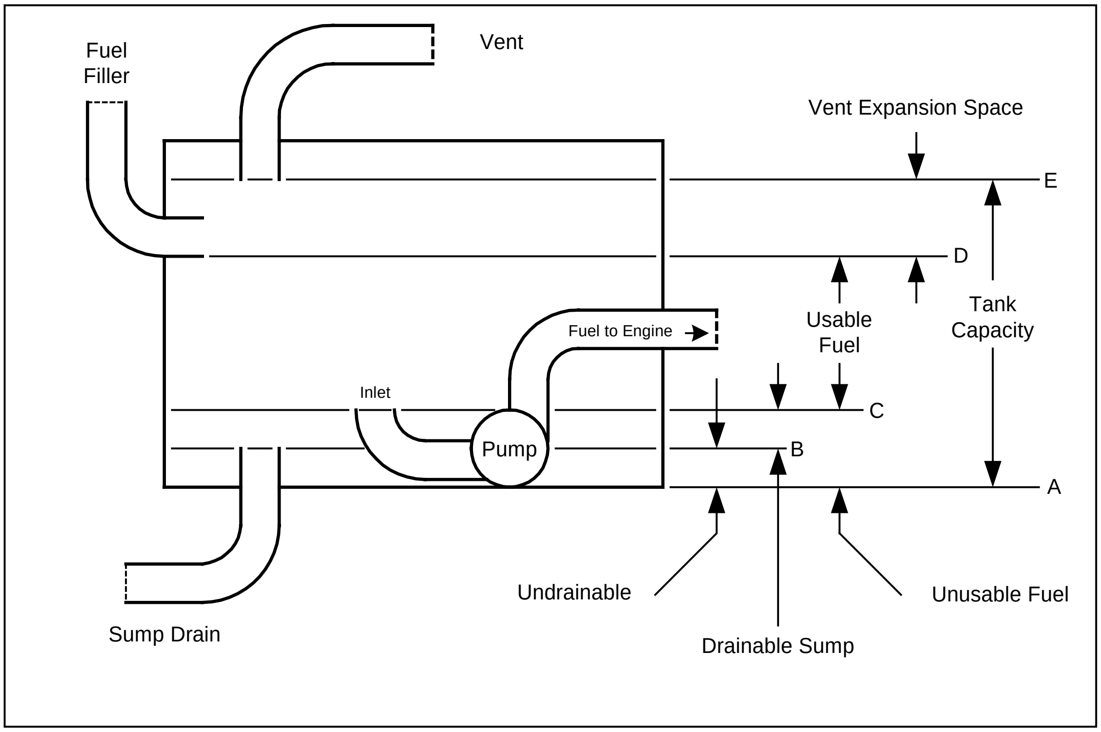
$\mathbf{V_{SO}}$ is the airplane stalling speed or the minimum steady flight speed in the landing configuration.

ACCEPTABLE MEANS OF COMPLIANCE:

The flight maneuvers discussed under **TEST PROCEDURES** (below) represent some conditions that may occur while in-service resulting in adverse fuel feed conditions.

A tank that is not used in all flight regimes need only be tested in the flight regime where it is used (e.g., cruise conditions). Tests for this kind of tank should include slips and skids to simulate turbulence. Provide limitations on the conditions under which the tank may be used in a placard or in the Airplane Flight Manual (AFM).

The term “most adverse fuel condition” includes radical or extreme maneuvers only if they are part of the intended flight envelope. Analyze the fuel system and tank geometry to determine the critical maneuvers for the specific tanks being considered (i.e., main, auxiliary, or cruise tanks). Determine the appropriate maneuvers for the type of airplane being tested and flight test those conditions. Ground tests using equipment that accurately simulates the airplane fuel systems and in-flight inertial effects may also be used. Alternatively, the applicant may establish a conservative unusable fuel quantity and conduct necessary tests to show engine malfunction will not occur. In this case, all the tests shown under **TEST PROCEDURES** below are considered appropriate; however, the method of conducting the test may vary from that used to determine the actual fuel quantity.



Fuel Level Representations

A	Completely empty tank.
B	Remaining fuel after draining tank using sump drain.
C	Remaining fuel after fuel pump has run dry.
D	Fuel quantity after tank has been "topped off."
E	Fuel quantity where fuel first enters vent system.

FIGURE 3

TEST PROCEDURES:

GENERAL

Conduct usable fuel tests under flight conditions and attitudes that are critical with respect to unusable fuel quantity. Likewise, evaluate any ground maneuvers such as taxi turns and turning takeoffs that may also be critical

Chose the minimum fuel quantity sufficient to perform the maneuvers described below. A minimum fuel quantity is most important as repeated maneuvers may result in the fuel refilling some bays or tanks .

For the purpose of these tests, only malfunctions attributable to fuel flow interruption are considered. Some examples are:

- Engine roughness;
- Partial or total loss of power;
- Fuel pressure reduced below minimum; or
- Fuel flow fluctuations.

To ensure the most conservative unusable fuel supply value for each tank, another fuel tank should be selected at the first indication of engine malfunction due to fuel interruption. The fuel remaining in the test tank at the time of malfunction is the unusable fuel. If header tanks (small tanks that accumulate fuel from one or more fuel tanks and supply the engine directly) are utilized, the fuel remaining in the header tank should be added to the unusable fuel, but are not shown on the fuel gauge marking.

Conduct all tests at the minimum practical weight or weight determined to be critical for the airplane being tested. When testing an airplane with a single-engine fuel tank, use a separate temporary fuel system to supply the engine after fuel interruption occurs.

UNUSABLE FUEL DETERMINATION

(1) Level Flight: Maximum Recommended Cruise Power

NOTE. If the airplane manufacturer does not specify Maximum Recommended Cruise Power, then operate engine at the maximum allowable power for continuous operation.

Condition a. —Straight coordinated flight. Perform the following until the first indication of interrupted fuel flow is observed:

Maintain straight coordinated flight (bank angles not exceeding 5°).

Condition b. —Turbulent Air. Perform the following until the first indication of interrupted fuel flow is observed:

Simulate turbulent air with +/- half-ball width oscillations at approximately the natural yawing frequency of the airplane in pitch, roll, and yaw.

Condition c. —Skidding turn in the direction most critical with respect to fuel feed. Repeat the following until the first indication of interrupted fuel flow is observed:

Maintain a skidding turn with 1-ball width skid for 30 seconds and return to coordinated flight for 1 minute.

(2) Climb: Maximum Climb Power at Best Angle-of-Climb Speed, V_X

NOTE. If the airplane manufacturer does not specify Maximum Climb Power, then operate engine at either the maximum allowable power for takeoff operation (maximum airplane weight over 6,000 lbs.), or maximum allowable power for continuous operation (maximum airplane weight 6,000 lbs. or less).

Condition a. —Straight coordinated flight. Perform the following until the first indication of interrupted fuel flow is observed:

Maintain straight coordinated flight (bank angles not exceeding 5°).

Condition b. —Turbulent Air. Perform the following until the first indication of interrupted fuel flow is observed:

Simulate turbulent air with +/- half-ball width oscillations at approximately the natural frequency of the airplane.

Repeat Condition c. —Skidding turn in the direction most critical with respect to fuel feed. the following until the first indication of interrupted fuel flow is observed:

Maintain a skidding turn with 1-ball width skid (or full rudder if 1-ball width cannot be obtained) for 30 seconds and return to coordinated flight for 1 minute.

(3) One-Engine Inoperative Climb: Maximum Climb Power at One-Engine Inoperative Best Rate-of-Climb Speed, V_{YSE}

NOTE. If the AFM does not specify Maximum Climb Power, then operate engine at either the maximum allowable power for takeoff operation (maximum airplane weight over 6,000 lbs.), or maximum allowable power for continuous operation (maximum airplane weight 6,000 lbs. or less).

Set the critical engine to zero thrust to simulate a critical engine-out condition (do not shut down the critical engine). Conduct a straight climb at the best rate of climb speed for one engine inoperative (V_{YSE}). Utilize the bank angle and ball displacement used in determining single-engine performance. Continue climb until a malfunction occurs.

(4) Descent and Approach

Condition a. —Emergency descent or rapid descent. Perform the following until the first indication of interrupted fuel flow is observed:

Make a continuous power-off straight descent at V_{FE} with gear and flaps down or follow emergency descent procedures contained in the AFM.

Condition b. —Perform the following until the first indication of interrupted fuel flow is observed:

Make a continuous power-off glide at 1.3 V_{SO}. Simulate turbulent air or smooth condition, whichever is most critical.

Starting from the most critical condition established above, verify that there is no interruption of fuel flow when performing the following:

Make a simultaneous application of Maximum Continuous Power (MCP) and a transition to best rate-of-climb speed, $V_{Y,}$ from a power-off glide at 1.3 V_{SO}.

Condition c. —Sideslip on approach.

This test is for 30 seconds or until the first indication of interrupted fuel flow is observed, whichever comes first:

Establish a 1.3 V_{SO} descent in a landing configuration. Maintain a 1½-ball sideslip in the direction most critical for the fuel feed system. (Use the maximum sideslip anticipated for the airplane if it is less than 1½-ball.) Maintain a constant heading using sufficient aileron.

TESTS TO BE CONDUCTED AFTER DETERMINING USABLE FUEL

Descent and Approach

(1) Verify (with the unusable fuel quantity established during critical tests) that no interruption of fuel flow will occur when simultaneously making a rapid application of MCP and a transition to V_Y from a power-off glide at 1.3 V_{SO}.

(2) Verify (with the unusable fuel quantity established during critical tests) that no interruption of fuel flow will occur when slipping for 30 seconds, followed by a maximum power straight ahead balked landing climb for 1 minute.

Taxi Turns and Turning Takeoffs

Chose the minimum fuel quantity sufficient to perform the maneuvers described below. This quantity should not exceed the flight unusable fuel supply plus 30 minutes of fuel supply at MCP (see **NOTE** below). Turns should be in the direction most adverse for the tank being used. Load the airplane to the approximate minimum flying weight or its critical weight. Any engine malfunction due to fuel interruption during this test sequence is not acceptable.

Make a maximum lateral gravity (g's) 90° turn rolling takeoff. (The maximum lateral g's turn is where lateral skidding is evident.) Immediately follow the takeoff with a 3-minute climb at best angle-of-climb speed for single-engine airplanes or speed determined under § 23.51 for multiengine airplanes. Follow normal flight procedures and maintain operating conditions necessary for safe operations (i.e., proper engine cooling).

Make a 360° clearing turn at a rate appropriate to the airplane, immediately followed by a takeoff and a 3-minute straight climb at best rate-of-climb speed for single-engine airplanes or the speed determined under § 23.51 for multiengine airplanes. Follow normal flight procedures and maintain operating conditions necessary for safe operations (i.e., proper engine cooling).

Make a 180° turn at normal taxi speed, immediately followed by a takeoff and a 3-minute climb at best rate-of-climb speed for single-engine airplanes or a speed determined under § 23.51 for multiengine airplanes. Follow normal flight procedures and maintain operating conditions necessary for safe operations (i.e., proper engine cooling).

NOTE. If the initial fuel quantity used during the above tests exceeds the 30-minute fuel supply at MCP, take the following actions:

- Mark the fuel quantity gauge with a yellow arc (appropriately placarded) from the unusable fuel ("zero" level) to a level corresponding to the amount of fuel used in the above tests.

- Add an AFM limitation restricting takeoff with the fuel quantity less than the top of the yellow arc.

Related Material

AC 20-88A, Guidelines on the Marking of Aircraft Powerplant Instruments (Displays).

(b) The preamble to Amendment 23-51 states paragraph (b) requires that, "The effect of any fuel pump failure on the unusable fuel supply be established. This change would not require any change in the fuel quantity indicator marking required by § 23.1553."

23.961 Fuel system hot weather operation (Amendment 23-43)

GENERAL:

The fuel system is to be free of vapor lock when operating the airplane in all critical operating and environmental conditions. Vapor lock occurs most frequently with hot fuel. Evaluate airplanes using aviation gasolines at the fuel's critical temperature with respect to vapor formation. Evaluate airplanes using jet or diesel fuel at the more critical temperature with respect to vapor formation of 110 °F (0 +5°) or the airplane's maximum allowable outside air temperature.

Procedures for conducting hot weather fuel tests on airplanes using automobile gasoline (autogas) are contained in AC 23.1521-1B, Type Certification of Automobile Gasoline in Part 23 Airplanes with Reciprocating Engines.

Test results referred to in this section were made at the William J. Hughes Technical Center in Atlantic City, New Jersey.

Several factors are involved in the evaluation of an airplane fuel system for hot weather. The applicant should consider at least the following:

(1) Fuel System Design

Fuel system designs should be in compliance with 14 CFR Part 23. In particular, do not route fuel lines close to hot exhaust systems as that may cause increased fuel temperature in the fuel lines.

Any fuel system (including gravity feed systems) using aviation or automobile fuels is conducive to vapor formation. Systems using a fuel pump with suction lift are highly susceptible to vapor formation.

(2) Determination of Critical Fuel Temperature

The likelihood of vapor formation and subsequent interruption of engine power increases with elevated fuel temperature up to 110 °F. The temperature value of 110 °F was derived from the distillation data pertinent to aviation and turbine fuels.

The tendency of various fuels to form vapor is different. Fuels such as automobile gasoline (autogas) have an initial boiling point of approximately 85 °F, whereas some turbine fuels have an initial boiling point of approximately 120 °F.

The distillation data for any other fuel should be analyzed and the appropriate test temperature chosen. If, for example, an applicant wanted to test an airplane with liquid hydrogen fuel, it would not be reasonable to require the fuel to be heated to

110 °F since the boiling point is -423 °F at one atmosphere pressure. The same logic should apply, regardless of what alternate fuel is being tested.

Distillation data, provided from the National Institute for Petroleum and Energy Research (NIPER), using the ASTM D-86 distillation method for ASTM D-910 aviation gasoline and winter-grade automotive gasoline, revealed autogas heated to 110 °F in a vented vessel (i.e., an airplane fuel tank) will boil off approximately 18 percent of its mass in the form of non-recoverable vapors. These lost constituents are primarily the high volatile fractions, mainly pentane and butane, are the exact same fuel constituents, and can cause vapor lock problems. In contrast, aviation gasoline will boil off approximately 1 percent of its mass when heated to 110 °F.

Since the initial boiling point is a vapor temperature, the actual fuel temperature for the initial boiling point is greater than the vapor temperature. The tendency to form vapor may be related to Reid Vapor Pressure (RVP) with the higher values being more conducive to vapor formation.

(3) Test Requirements for Demonstrating Compliance

A flight test is normally necessary to complete the hot weather operation tests at the critical operating conditions including; maximum fuel flow, highest angle of attack (for tractor propeller aircraft), maximum fuel temperature, etc. If supplemental ground testing is performed, it should closely simulate flight conditions.

In the case of small airplanes with shallow depth fuel tanks, the actual fuel level in the tanks has had very little affect on hot weather test results.

(4) Other

Fuel temperatures will be significantly higher than the ambient air temperature if the airplane has been parked in direct sunlight.

DEFINITIONS:

Initial boiling point

The vapor temperature at which the first drop of liquid fuel is observed after passing vapor through a distillation test apparatus.

Fuel volatility

The fuel’s tendency to evaporate (change to a vapor from a fluid).

Vapor lock

Vapor lock is the tendency of a liquid to form vapor in fuel lines, pumps, etc., that would restrict liquid fuel flow to the engine and interrupt combustion.

True vapor pressure

True vapor pressure is the pressure exerted by its vapor in equilibrium with the liquid at a specific temperature with the absence of air over the fuel.

Weathering

Weathering is the reduction of fuel volatility when given sufficient time, agitation, temperature cycles, and/or pressure changes.

ACCEPTABLE MEANS OF COMPLIANCE:

Perform hot weather operation tests only with outside air temperatures 85 °F or higher measured at 4- to 6-feet above the runway surface.

Conduct the tests with the fuel system operating normally per the Airplane Flight Manual (AFM). Do not operate the emergency fuel pumps if they are being considered for use as backup pumps. This test may be used to establish the maximum pressure altitude for operation with the pumps off.

Do not allow the test fuel to weather, which includes exposure to the atmosphere overnight, as this may have a significant effect on the RVP. This ensures that the fuel has the maximum RVP. Take fuel samples just prior to the test to establish that the fuel's vapor pressure is correct.

Set the airplane weight with critical fuel level in the critical fuel tank, minimum crew necessary for safe operation, and the ballast necessary to maintain the center of gravity within allowable limits. If the critical fuel tank cannot be positively identified, then the hot weather operation tests should be repeated for the other tank(s). The critical fuel level in most cases would be low fuel; however, full fuel can be critical.

If required, heat the fuel in the shortest time period possible without causing excessive local temperature conditions at the heat exchanger, optimally less than 90 minutes, but not to exceed 180 minutes. It is not necessary to provide additional heat to the fuel system after this initial heating is completed. Raise the temperature of the fuel to the critical value with respect to vapor formation as follows:

(1) For aviation gasoline, 110 °F (-0 to +5 °F), and

(2) For turbine fuel, 110 °F (-0 to +5 °F).

There are several methods of heating the fuel such as:

(1) Circulating hot water or steam through a heat exchanger placed in the fuel tank to increase the fuel temperature, or

(2) Placing black plastic or other material on the fuel tanks in bright sunlight, or

(3) Blowing hot air over the fuel tank.

NOTE. Do not agitate or excessively handle the fuel during the heating process.

CAUTION: Heating and handling fuel at elevated temperatures is hazardous to ground and flight personnel; therefore, every safety precaution should be taken.

If the outside ambient conditions interfere with the ability to conduct a valid test, it may be necessary to insulate fuel tank surfaces, fuel lines, and other fuel system components.

Perform the following as soon as possible after the fuel in the tank reaches the required test temperature:

Perform a maximum power takeoff and climb. (This ensures maximum fuel flow rates.) Use the same climb airspeed used in demonstrating the requirements specified in § 23.65. Continue the climb to the maximum operating altitude approved for the airplane.

NOTE. It is not necessary for the engine oil temperature to be at maximum, although it should be at least the minimum recommended for takeoff.

Record the following data, at minimum, throughout the test:

- Fuel temperature in the tank;
- Fuel pressure at the start of the test and continuously during climb, noting any loss of pressure, fluctuation, or variations;
- Main and emergency fuel pump operation, as applicable;
- Pressure altitude;
- Ambient air temperature, total or static as applicable;
- Airspeed;

- Engine power (i.e., engine pressure ratio, gas generator speed, torque, r.p.m.), turbine inlet temperature, exhaust gas temperature, manifold pressure, and fuel flow, as appropriate;

- Comments on engine operation;

- Fuel quantity in the fuel tank(s) during takeoff;

- Fuel vapor pressure for autogas only, determined prior to test; and

- Fuel grade or designation, determined prior to test.

The test is passed if:

- The fuel pressure is at or above the minimum prescribed by the engine manufacturer;

- The fuel pressure does not fluctuate excessively; and

- There is no engine malfunction due to fuel interruption throughout the test.

If fuel pressure fluctuations occur, but the test is otherwise passed, consider additional testing requirements to determine that pressure failure may not occur during any expected operating mode. Also, evaluate the fuel system for vapor formation during cruise flight at maximum approved altitude in smooth air at low to moderate power setting, and low fuel flow and idling approach to landing.

Document instructions for proper fuel pump use during hot weather operation in the AFM. Also, document any limitations on the outside air temperature in the AFM.

23.963 Fuel tanks: General (Amendment 23-51)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

23.965 Fuel tank tests (Amendment 23-51)

(a) No policy available as of March 11, 1996.

(b) The vibration tests are necessary for any tank with a capacity of more than 10 gallons constructed in a wide flat shape with no baffles. It is acceptable to test the portion of the wing encompassing the tank(s) with a suitable amount of structure extending on all sides provided the support is representative. If there are several tanks spanwise, it may be desirable to test the entire wing, thus substantiating all tanks at the same time. If the entire wing span is wet, then test the entire structure.

The tests ***may not*** be required if:

- The tanks include internal baffles (not exceeding 15-in. apart in length and width); or
- The tank is constructed of a .050 inch or more thick aluminum alloy and the tank uses “suitable” joints. Joining methods can be determined “suitable” based upon design characteristics and relevant service experience.

The tests ***are necessary***, even if the above are met, if any permanent set is observed in the baffles or their attachments during the pressure test.

Refer to AC 23-15, Small Airplane Certification Compliance Program, for fuel tanks with less than a 10-gallon capacity.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

23.967 Fuel tank installation (Amendment 23-43)

(a) Current policy on § 23.967(a)(6) applies the prohibition against fuel siphoning only to bladder (flexible) fuel tanks. A legal review of the regulation has concluded that the intent of this paragraph is to prevent the fuel loss and associated fuel quantity measuring inaccuracies in collapsed bladder cells due to filler openings being left uncovered. This policy applies to ground and flight operations.

Minor spillage applies to ground operation only. The definition of ***minor*** is “upon removal of the filler cap, no fuel makes it from the filler opening to the surface upon which the airplane is resting.”

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) Compliance with § 23.967(e)(1) may be demonstrated by analysis alone, provided sufficient margin can be shown to ensure that fuel leakage is such that no hazard to occupants results.

Related Material

AC 20-107A, Composite Aircraft Structure.

23.969 Fuel tank expansion space (Original)

No policy available as of March 11, 1996.

NOTE. Fuel tank expansion space is illustrated in Figure 3 of this AC under section 23.959.

23.971 Fuel tank sump (Amendment 23-43)

(a) The fuel tank sump functions as an operational trap for contaminants. The fuel tank sump may be located either within the fuel tank, or outside of the fuel tank, provided the tank is drainable to the sump.

A single fuel tank sump may serve multiple fuel tanks provided:

(1) The fuel tanks are interconnected to function as a single tank, and

(2) The fuel tanks are completely drainable to one tank.

While Part 23 does not require fuel cross-feed capabilities, airplanes with fuel cross-feed systems should also incorporate fuel tank sumps to prevent contaminated fuel from entering the engine.

(b) Design each fuel tank to allow drainage of any “hazardous” quantity of water from any part of the fuel tank, to its sump, with the airplane in the “normal ground attitude” within a reasonable period of time.

“Normal ground attitude” is defined as “the aircraft ground attitude that would normally be expected in service.” Therefore, consideration of nose wheel strut, main gear strut, variation of all landing gear tires, and the apron gradient is necessary. Use a minimum ground slope of 1 percent for determination of fuel tank sump capacity. An appropriate slope for seaplanes/amphibian airplanes would have to be determined from the worst case static in-water attitude of the aircraft at the most adverse center of gravity location(s).

The term “hazardous” was incorporated by Amendment 23-43 (55 FR 40598, October 3, 1990) based on service experience that reciprocating engine airplane fuel systems are susceptible to water collecting in the fuel tanks. Prior to Amendment 23-43, tank sumps or a sediment bowl/chamber arrangements could be approved that do not always prevent water from reaching the engine, especially in tank configurations with flexible liners.

Related Material

AC 20-43C, Aircraft Fuel Control.

AC 20-116, Marking Aircraft Fuel Filler Openings with Color Coded Decal.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

23.973 Fuel tank filler connection (Amendment 23-51)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) The fuel-filler opening dimensional restrictions specified in § 23.973(e) and (f) were incorporated by Amendment 23-43 (55 FR 40598, October 3, 1990) to prevent turbine fuel from being put into tanks of airplanes that operate only on gasoline. The dimensions were established through discussions with airplane manufacturers, fuel suppliers, and pertinent industry associations. In addition, airplanes in-production at that time were found to comply with the proposed dimensions.

Related Material

AC 20-122A, Anti-misfueling Devices: Their Availability and Use.

(f) No policy available as of March 11, 1996. (See also paragraph (e) above.)

23.975 Fuel tank vents and carburetor vapor vents (Amendment 23-51)

Some general information on this subject is found in this AC under sections 23.951, 23.955, and 23.959 of this document.

(a) Section 23.975(a)(3) refers to excessive pressure differences between the interior and exterior of the fuel tank. The characteristics and consequences of excessive difference in pressure will depend on the type and material of the tank. For instance, excessive differences in pressure for a bladder-type tank would result in deformation in the bladder resulting in an erroneous fuel quantity indication. Adequate positive pressure should remain within the bladder tank. For an integral tank system, excessive difference in pressure may result in collapse or structural failure of the tank and supporting structure.

Compliance with the requirements of § 23.975(a) is typically accomplished through a combination of design review and testing (both ground and flight testing).

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

23.977 Fuel tank outlet (Amendment 23-43)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

23.979 Pressure fueling systems (Amendment 23-51)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

FUEL SYSTEM COMPONENTS

23.991 Fuel pumps (Amendment 23-43)

(a) No policy available as of March 11, 1996.

(b) Paragraphs (b) and (c) are interrelated and the interpretation of § 23.991(c) should consider § 23.991(b).

Both the main and emergency fuel pumps may operate continuously (simultaneously) provided there is a means to immediately indicate to the crew (in-flight) a malfunction of either pump.

An emergency fuel pump can sustain engine operation at full power in the event the engine-driven fuel-injector pump fails. An auxiliary fuel pump can provide some fuel flow during emergency operations, but not enough to sustain engine operation at full power. Its function is to aid in priming the engine and for suppressing fuel vapors

Some fuel injection systems utilize an integral speed-sensing pump, approved as part of the engine type design that delivers fuel at a (unregulated) pressure proportional to engine speed. Such systems have fuel lift capability that enables the system to function with a negative inlet pump pressure within specific limits as indicated by the engine type certificate data sheet (TCDS). For these types of fuel systems, an emergency fuel pump is not required when the injection pump is approved as part of the engine under § 23.991(b).

Other fuel injection systems require an essentially constant (regulated) fuel pressure to the fuel-injector inlet. The acceptable pressure limits are specified on the engine TCDS. In these systems, the engine-driven fuel pump is functionally independent of the engine and not tied to the type design (regardless of the fuel pump supplier). Consequently, these systems do require an emergency pump (per 14 CFR Part 23, § 23.991(b)) to ensure engine operation is sustained should the engine-driven pump fail.

(c) See paragraph (b) above.

(d) No policy available as of March 11, 1996.

23.993 Fuel system lines and fittings (Amendment 23-43)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) The term “suitable for a particular application” was incorporated by Amendment 23-43 (55 FR 40598, October 3, 1990) to remove the words “must be approved or.” This wording makes § 23.993(d) more restrictive. All components are “approved” if they are installed on a certificated airplane; however, this in itself does not guarantee suitability. For example, fuel hoses could be “approved” through the Technical Standard Order (TSO) system, but still not “suitable” for the environment of a particular installation.

(e) No policy available as of March 11, 1996.

23.994 Fuel system components (Amendment 23-29)

For the purpose of this section, “hazardous quantity” is defined as one quart, except a greater amount may escape if that greater amount can be substantiated as non-hazardous.

23.995 Fuel valves and controls (Amendment 23-29)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

(f) No policy available as of March 11, 1996.

(g) No policy available as of March 11, 1996.

23.997 Fuel strainer or filter (Amendment 23-43)

Turbine engines certificated to 14 CFR Part 33, § 33.67, Fuel system, Amendment 33-6 or subsequent, will include a fuel filter complying with § 23.997; no airframe-supplied filter is required. Turbine engines certificated prior to § 33.67, Amendment 33-6, may require an airframe-supplied filter.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

Related Material

AC 23-15, Small Airplane Certification Compliance Program.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

Related Material

AC 23.1419-2A, Certification of Part 23 Airplanes for Flight in Icing Conditions.

23.999 Fuel system drains (Amendment 23-43)

(a) Usually more than one drain valve is required to drain the entire fuel system. These are typically located in fuel tank sumps, fuel line low spots, and in fuel filter/strainers.

(b) Spring-loaded drain valves may be used to comply with the positive locking provision of this paragraph in any region of positive fuel pressure. If a spring-loaded valve is located in a negative fuel pressure region (e.g., upstream of an engine-drive fuel pump providing suction lift), substantiate the installation by a test.

23.1001 Fuel jettisoning system (Amendment 23-51)

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

(f) No policy available as of March 11, 1996.

(g) No policy available as of March 11, 1996.

(h) No policy available as of March 11, 1996.

OIL SYSTEM

23.1011 General (Amendment 23-43)

(a) Oil systems and components certified with the engine may or may not be suitable for use in a specific airplane installation, depending upon the test/analysis performed at the time. Also, engines may be originally certified with the intention of being installed in different airplanes than where they are eventually used. Consequently, oil systems and components approved during engine type certification are only acceptable for use without further substantiation when the standards were equal or more severe than those in this Subpart.

Evaluate each pertinent item in the installation to assess the severity of the airplane requirements versus the requirements demonstrated during engine certification. Verify the latter with the engine manufacturer or the FAA office controlling the engine type design.

(b) No policy available as of March 11, 1996.

(c) DISCUSSION:

Paragraph 23.1011(c) requires that, “The usable oil tank capacity may not be less than the product of the endurance of the airplane under critical operating conditions and the maximum oil consumption of the engine under the same conditions, plus a suitable margin to ensure adequate circulation and cooling.” In other words, there needs to be enough oil (usable supply) to allow the engine to consume the usable fuel. This should be substantiated by a quantitative analysis.

In addition, a suitable oil quantity margin for system circulation is necessary for all engine installations. The oil system should be capable of maintaining the engine within its operating limitations (i.e., oil temperature with the minimum oil quantity provided for circulation). Cooling tests do not need to be performed with a low usable oil supply provided the oil is properly cooled at all oil levels.

DEFINITIONS:

Usable Oil

Usable oil is defined as the quantity of oil in the oil tank (or sump in the case of wet sump engines) in excess of the minimum quantity of oil required to keep the oil pump inlet feed covered under the most adverse operating condition.

In the absence of any other data, the most severe of the following two conditions may be used as the most adverse operating condition (in both cases, with the airplane at a zero-degree roll angle):

(1) The nose-up pitch angle required for the sea level best rate-of-climb speed with maximum continuous power, or

(2) The nose-down pitch angle required for the 1.3 V_{SO} power-off landing configuration.

For most wet sump engines, the usable oil quantity for various pitch angles is listed on the appropriate engine Type Certificate Data Sheet (TCDS). This quantity may be used instead of a determination of usable oil as described above. If the usable quantity is not listed, it may be determined by contacting the engine manufacturer or conducting a usable oil test with the critical operating conditions.

Usable Fuel

The usable quantity of fuel is established under § 23.959.

Specific Oil Consumption (SOC)

The SOC is the maximum oil consumption rates established by the engine's manufacturer, expressed in pounds per brake horsepower per hour (lb./bhp/hr.). If such a maximum oil consumption rate is not available, use 0.012 lb./bhp/hr. for reciprocating engines. There is no similar "default" maximum oil consumption rate for turbine engines.

You can also establish an oil consumption rate by:

(1) **Statistical analysis of actual in-service oil consumption rates**. The analysis should include observed data on the actual oil consumption from statistically valid sample engines of the same model. These data should be obtained from high time engines or those with high oil consumption just prior to removal for overhaul.

(2) **Testing per an FAA-approved test plan**. Testing for a lower oil consumption rate should include a positive demonstration that a lower oil consumption rate will not jeopardize the airworthiness of the engine.

Specific Fuel Consumption (SFC)

SFC is the fuel consumption established for the engine based on available engine power expressed in pounds per brake horsepower per hour.

ACCEPTABLE MEANS OF COMPLIANCE:

Single-engine Installations

Determine the **minimum** allowable usable oil capacity from the airplane's endurance (~total fuel capacity divided by the minimum SFC) and the maximum allowable oil consumption rate. For either wet or dry sump engines, this is expressed mathematically as follows:

$$[\text{Minimum Usable Oil Capacity (lbs.)}] = \frac{[\text{Maximum Usable Fuel Capacity (lbs)}] \times [\text{Maximum SOC (lb./bhp/hr.)}]}{[\text{Minimum Obtainable SFC (lb./bhp/hr.)}]}$$

A usable oil capacity greater than or equal to the calculated number above is acceptable.

Multiengine Installations

Calculate the minimum usable oil capacity for a multiengine aircraft as above, except modify as follows:

Account for the additional usable fuel if the airplane has a fuel cross-feed system or common fuel tank in the event of an engine shutdown. Allocate 50 percent of the maximum usable fuel capacity attributable to the shutdown engine as available to the other engine(s). For example, for a twin-engine airplane with 1,000 pound maximum usable fuel, 500 pounds of which is attributed to the shutdown engine, then add 50 percent of that (250 pounds) to the available fuel.

In addition, adjust the fuel consumption of the remaining engine(s) to reflect any power or mixture setting changes made to complete the flight safely.

(d) A conventional system (no transfer system provided) should only consider the usable oil tank or sump capacity in the determination of the usable oil supply. Do not consider the quantity of oil in the engine oil lines, in the oil radiator, oil filter, propeller feathering reserve, etc. If the airplane manufacturer elects to operate the engine with less than total oil capacity, the lower oil level should be used in the analysis.

(e) When an oil reserve system is installed, additional oil may be available. The system is often configured so the transfer pump can pump oil into the main engine oil tank(s) from the transfer lines. In this case, include the quantity of oil that would be pumped to the main engine oil tank(s) in the determination of the usable oil supply.

23.1013 Oil tanks (Amendment 23-51)

Related Material

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

NOTE. In the event of differences between AC 20-135 and AC 23-2 (see below for AC title), the applicant may choose whichever advisory circular is most applicable and/or advantageous.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

Related Material

AC 23-2, Flammability Tests.

(f) No policy available as of March 11, 1996.

(g) No policy available as of March 11, 1996.

23.1015 Oil tank tests (Amendment 23-15)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

23.1017 Oil lines and fittings (Amendment 23-14)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

23.1019 Oil strainer or filter (Amendment 23-43)

(a)(3) The engine oil pressure indication may be used as a method of detecting oil filter/strainer contamination provided the applicant demonstrates a procedure that does the following:

- Identifies the oil strainer/filter contamination, and
- Isolates the contamination as the sole cause of an indicated oil pressure change.

(a)(5) A red warning light is one means of complying with § 23.1019(a)(5).

(b) No policy available as of March 11, 1996.

23.1021 Oil system drains (Amendment 23-43)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

23.1023 Oil radiators (Original)

No policy available as of March 11, 1996.

23.1027 Propeller feathering system (Amendment 23-43)

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

COOLING

23.1041 General (Amendment 23-51)

For reciprocating engines, cooling climb tests are typically commenced at pressure altitudes below 5,000 feet. However, the applicant should ensure that the chosen test conditions are the most adverse with respect to demonstrating engine cooling.

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

23.1043 Cooling tests (Amendment 23-51)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

23.1045 Cooling test procedures for turbine engine powered airplanes (Amendment 23-51)

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

23.1047 Cooling test procedures for reciprocating engine powered airplanes (Amendment 23-51)

No policy available as of March 11, 1996.

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

LIQUID COOLING

23.1061 Installation (Amendment 23-43)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

(f) No policy available as of March 11, 1996.

23.1063 Coolant tank tests (Original)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

INDUCTION SYSTEM

23.1091 Air induction system (Amendment 23-51)

Related Material

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

Related Material

AC 23-2, Flammability Tests.

(c)(1) No policy for § 23.1091(c)(1) available as of March 11, 1996.

(c)(2) No policy for § 23.1091(c)(2) available as of March 11, 1996.

Related Material

AC 20-124, Water Ingestion Testing for Turbine Powered Airplanes.

23.1093 Induction system icing protection (Amendment 23-51)

All normal, utility, acrobatic, and commuter category airplanes certificated under Part 23 are to comply with this section, even if the airplane is ***not*** being certificated for flight into known icing conditions. These requirements are in addition to those demonstrated during engine certification (reference 14 CFR Part 33, Subpart E, § 33.68, Induction system icing, for turbine aircraft engines). (An exemption to this requirement may be possible for single-engine piston or turbopropeller airplanes certificated under the provisions of 14 CFR Part 21, § 21.25(a), for special purpose agricultural operations.)

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

AC 23.1521-1B, Type Certification of Automobile Gasoline in Part 23 Airplanes with Reciprocating Engines.

(a) Testing is normally required to demonstrate compliance, as analytical methods have been difficult to validate.

Related Material

AC 23.1419-2A, Certification of Part 23 Airplanes for Flight in Icing Conditions.

(b) No policy available as of March 11, 1996

Related Material

AC 20-73, Aircraft Ice Protection.

(c) No policy available as of March 11, 1996

23.1095 Carburetor deicing fluid flow rate (Original)

(a) No policy as of March 11, 1996.

(b) No policy as of March 11, 1996.

23.1097 Carburetor deicing fluid system capacity (Original)

(a) No policy as of March 11, 1996.

(b) No policy as of March 11, 1996.

23.1099 Carburetor deicing fluid system detail design (Original)

No policy as of March 11, 1996.

23.1101 Induction air preheater design (Amendment 23-43)

(a) No policy as of March 11, 1996.

(b) No policy as of March 11, 1996.

(c) No policy as of March 11, 1996.

23.1103 Induction system ducts (Amendment 23-43)

(a) No policy as of March 11, 1996.

(b) No policy as of March 11, 1996.

(c) No policy as of March 11, 1996.

(d) No policy as of March 11, 1996.

(e) No policy as of March 11, 1996.

(f) No policy as of March 11, 1996.

23.1105 Induction system screens (Amendment 23-51)

(a) No policy as of March 11, 1996.

(b) No policy as of March 11, 1996.

(c) No policy as of March 11, 1996.

(d) No policy as of March 11, 1996.

23.1107 Induction system filters (Amendment 23-51)

(a) The filter media should be resistant to fuel, oil, water, normally used cleaning materials, and other engine/airplane fluids in the powerplant installation. It should also be flame resistant.

Gasket material and adhesives should also be resistant to fuel, oil, water, normally used cleaning materials, and other engine/airplane fluids in the powerplant installation. They should not deteriorate from exposure to engine compartment temperatures.

(b) Design the filter installation to preclude the release of pieces of the filter and/or gasket material into the intake airstream. These failures are critical as they can result in a power loss. One methodology is to provide screens or other restraints to prevent failed pieces from moving downstream and interfering with the fuel metering components.

23.1109 Turbocharger bleed air system (Amendment 23-42)

(a) No policy as of March 11, 1996.

(b) No policy as of March 11, 1996.

23.1111 Turbine engine bleed air system (Amendment 23-17)

(a) No policy as of March 11, 1996.

(b) No policy as of March 11, 1996.

(c) No policy as of March 11, 1996.

EXHAUST SYSTEM

23.1121 General (Amendment 23-51)

Use the following guidelines for exhaust system installations:

- Provide sufficient clearance and/or heat shielding between exhaust components and spark plugs, plug leads, mount isolators, induction systems, engine controls, fuel systems, and other heat-sensitive airframe components.

- The exhaust system should be accessible for inspections. Adequately support all exhaust components such as tail pipes, heat exchangers, and mufflers.

- Provide slip joints or other suitable components in the exhaust system to address thermal expansion and engine movement. Locate any such components so minor leakage does not impinge on components or contaminate the cabin air.

Related Material

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

(a) No policy as of March 11, 1996.

Related Material

AC 20-32B, Carbon Monoxide (CO) Contamination in Aircraft—Detection and Prevention.

(b) No policy as of March 11, 1996.

(c) No policy as of March 11, 1996.

Related Material

AC 23-2, Flammability Tests.

AC 20-107A, Composite Aircraft Structure.

(d) No policy as of March 11, 1996.

(e) No policy as of March 11, 1996.

(f) No policy as of March 11, 1996.

(g) No policy as of March 11, 1996.

(h) No policy as of March 11, 1996.

(i) No policy as of March 11, 1996.

23.1123 Exhaust system (Amendment 23-43)

Related Material

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

(a) No policy available as of March 11, 1996.

Related Material

AC 23-2, Flammability Tests.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

23.1125 Exhaust heat exchangers (Amendment 23-17)

(a) The intent of § 23.1125(a)(3) is that cooling air is to flow through the heat exchanger whenever and wherever exhaust gases are in contact with the heat exchanger.

(b) No policy available as of March 11, 1996.

POWERPLANT CONTROLS AND ACCESSORIES

23.1141 Powerplant controls: General (Amendment 23-51)

Related Material

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

(a) Airplanes may be equipped with single-lever power controls (a control arrangement allowing both the engine throttle and propeller pitch control to operate via one lever) where the propeller pitch varies with engine r.p.m. by means of a mechanical cam or slider device as a function of throttle position. Any such propeller control system must be shown to have the level of integrity and reliability of a typical installation with independent propeller and throttle controls.

(b) No policy available as of March 11, 1996.
.
(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

(f) No policy available as of March 11, 1996.

Related Material:

AC 23-2, Flammability Tests.

(g) No policy available as of March 11, 1996.

23.1142 Auxiliary power unit controls (Amendment 23-43)

No policy available as of March 11, 1996.

23.1143 Engine controls (Amendment 23-51)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.
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(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

Related Material:

AC 20-136, Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning.

(f) No policy available as of March 11, 1996.

(g) No policy available as of March 11, 1996.

23.1145 Ignition switches (Amendment 23-43)

(a) This paragraph applies to both turbine and reciprocating engines. The required ignition switch may be used to select any position such as continuous, automatic, on, or off.

(b) On turbine engines incorporating an auto-relight system, one acceptable means of complying with the shutoff provision would be to have the shutoff switch activated by the power lever. Adequate instruction should be available to the pilot.

(c) No policy available as of March 11, 1996.

23.1147 Mixture controls (Amendment 23-43)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

23.1149 Propeller speed and pitch controls (Original)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

23.1153 Propeller feathering controls (Amendment 23-51)

No policy available as of March 11, 1996.

Related Material

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

23.1155 Turbine engine reverse thrust and propeller pitch settings below the flight regime (Amendment 23-7)

The FAA has long recognized the hazard of inadvertent operation of propeller reversing systems. Prior to the commercial use of turbine-powered airplanes, a few reciprocating engine-powered airplane designs included propeller reversing systems and were addressed by Civil Air Regulations (CAR) paragraph 4b. Section 23.1155 was added to Part 23 with Amendment 23-7 (1969) and applied to turbine-powered airplanes only. In the event of a Part 23 reciprocating engine-powered airplane using propeller-reversing systems, special conditions should be developed.

23.1157 Carburetor air temperature controls (Original)

No policy available as of March 11, 1996.

23.1163 Powerplant accessories (Amendment 23-42)

(a) Paragraph (a)(1) refers to provisions for mounting items such as brackets, isolating bushings, belt tension arms, belts, and other hardware up to, but not including, mounting lugs on the accessory. These provisions are to be approved under the engine Type Certificate (TC).

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

23.1165 Engine ignition systems (Amendment 23-34)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

(f) No policy available as of March 11, 1996.

POWERPLANT FIRE PROTECTION

23.1181 Designated fire zones; regions included (Amendment 23-51)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

23.1182 Nacelle areas behind firewalls (Amendment 23-14)

No policy available as of March 11, 1996.

Related Material

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

AC 20-107A, Composite Aircraft Structure.

23.1183 Lines, fittings, and components (Amendment 23-51)

Related Material

AC 20-107A, Composite Aircraft Structure.

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

(a) No policy available as of March 11, 1996.

Related Material

AC 23-2, Flammability Tests.

(b) No policy available as of March 11, 1996.

23.1189 Shutoff means (Amendment 23-43)

Related Material

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

Related Material

AC 23-2, Flammability Tests.

AC 23-8A with Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

AC 20-107A, Composite Aircraft Structure.

(c) No policy available as of March 11, 1996.

23.1191 Firewalls (Amendment 23-51)

Related Material

AC 23-2, Flammability Tests.

AC 20-107A, Composite Aircraft Structure.

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) Reserved.

(e) No policy available as of March 11, 1996.

(f) No policy available as of March 11, 1996.

(g) No policy available as of March 11, 1996.

23.1192 Engine accessory compartment diaphragm (Amendment 23-14)

No policy available as of March 11, 1996.

Related Material

AC 23-2, Flammability Tests.

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

23.1193 Cowling and nacelle (Amendment 23-43)

Related Material

AC 23-2, Flammability Tests.

AC 20-107A, Composite Aircraft Structure.

AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) Cowlings fabricated of Alclad Aluminum Alloy 2024-T3 (0.032-in. thickness) are considered fire resistant.

Conduct tests to substantiate alternate materials using an airflow velocity not more than minimum stall speed of the airplane on the exterior side of the test specimen.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

(f) No policy available as of March 11, 1996.

(g) No policy available as of March 11, 1996.

23.1195 Fire extinguishing systems (Amendment 23-43)

Related Material

AC 20-100, General Guidelines for Measuring Fire Extinguishing Agent Concentrations in Powerplant Compartments.

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

23.1197 Fire extinguishing agents (Amendment 23-34)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

23.1199 Extinguishing agent containers (Amendment 23-34)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

Related Material

AC 23.1419-2A, Certification of Part 23 Airplanes for Flight in Icing Conditions.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

23.1201 Fire extinguishing systems materials (Amendment 23-34)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

23.1203 Fire detector system (Amendment 23-51)

(a) No policy available as of March 11, 1996.

(b) No policy available as of March 11, 1996.

(c) No policy available as of March 11, 1996.

(d) No policy available as of March 11, 1996.

(e) No policy available as of March 11, 1996.

Related Material

AC 23-2, Flammability Tests.