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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 33

[Docket No. 93–ANE–14; No. 33–ANE–01]

Special Conditions; Soloy Corporation, Soloy Dual Pac Engine (Formally Soloy Dual Pac, Inc.)

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final special conditions.

SUMMARY: These special conditions are issued for the Soloy Corporation, Soloy Dual Pac engine (formally Soloy Dual Pac Inc.). This engine will have a novel design feature associated with its configuration. The Soloy Dual Pac engine is a propulsion system in which two Pratt & Whitney Canada (PWC) Model PT6 turbine engines are combined through a common gearbox to drive a single output propeller shaft. The Soloy Dual Pac engine is intended to provide a degree of continuous operation following the failure of one of the PWC Model PT6 engines. The applicable regulations do not contain adequate or appropriate safety standards for such a configuration. These special conditions contain the additional safety standards which the Administrator considers necessary to establish a level of safety equivalent to that established by the airworthiness standards of part 33 of the Federal Aviation Regulations (FAR).

EFFECTIVE DATES: March 21, 1997.

FOR FURTHER INFORMATION CONTACT:

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SUPPLEMENTARY INFORMATION:

Background

General

On November 9, 1990, Soloy Corporation applied for a supplemental type certificate for the Soloy Dual Pac engine. The Soloy Dual Pac engine is a propulsion concept in which two PWC Model PT6 engines, currently approved under Type Certificate No. E4EA, drive a single propeller shaft through a combining gearbox. The Soloy Dual Pac engine incorporates redundant freewheeling, drive, governing, and lubricating systems. A system of one-way clutches both prevents the propeller shaft from driving the engine input shafts and allows either engine to drive the propeller should the other engine fail. The supplemental type certificate for the Soloy Dual Pac engine is to be based on the type certificate of the PWC Model PT6 engine. On February 4, 1994, the FAA published a notice of proposed special conditions (59 FR 5356) for ''Soloy Dual Pac, Inc., Soloy Dual Pac Engine'', requesting public comments. Since that publication, the name has changed from Soloy Dual Pac, Inc., to Soloy Corporation.

Safety Analysis

The certification basis of the PWC Model PT6 engine was established before the introduction of § 33.75 of the Federal Aviation Regulation (FAR) (Safety Analysis). Section 33.75 addresses four types of engine failure conditions which are particularly hazardous to the safety of the aircraft. The objective of § 33.75 is to require an analysis to be performed at the engine level which establishes that any probable single or multiple failure, or any probable improper operation will not cause the engine to catch fire, burst, generate loads greater than the ultimate loads for the engine mount, or lose the capability to shut down. Consequently, it is considered appropriate to add a safety analysis requirement to the Soloy Dual Pac engine program.

Also, one objective of the Soloy Dual Pac engine is to provide continued operation after the failure of one PWC Model PT6 engine. While the safety analysis regulations of § 33.75 are more extensive than those of the PWC Model PT6 engine certification basis, they still do not address this special ''continue to run'' objective.

Therefore, in light of the above, it was proposed that a safety analysis requirement, modeled after § 33.75 and expanded to address continued operation after a single engine failure, be included in the Soloy Dual Pac engine certification basis.

Uncontained Engine Failure

It is assumed that the Soloy Dual Pac engine is intended for use in an aircraft and will be part of an aircraft certification program in the future. Minimizing the hazards to the aircraft from uncontained engine debris will be a very important requirement in any such certification program. In addition, for a design such as the Dual Pac, many design features intended to minimize such hazards would be determined at the engine design stage. Therefore, this issue must be addressed initially during the Soloy Dual Pac engine certification program, and may also be addressed during the aircraft installation certification program.

As stated above, one objective of a Soloy Dual Pac engine-equipped aircraft could be continued safe flight and landing after the failure of one PWC Model PT6 engine. In order for the Soloy Dual Pac engine to achieve this objective, it must continue to produce adequate and controllable torque after such a failure. Service experience, however, shows that uncontained engine failures can result in high velocity fragment penetration of, among other things, other engines. This could render the other engine inoperative as well. In the case of the Soloy Dual Pac engine, such an event could end all torque production. Therefore, the Soloy Dual Pac engine must demonstrate that the two PWC Model PT6 engines should be protected from each other in order to minimize the hazards associated with this event.

Gearbox Design, Functioning, and Endurance Testing

Power transmission systems, such as gearboxes, have not been specifically addressed by engine certification regulations. Previously, engines incorporating gearboxes, such as fan reduction gearing or accessory gearboxes, have been evaluated during the course of engine block tests and other engine certification activities. Transmissions such as those used in rotorcraft, however, have been addressed in rotor drive criteria contained in rotorcraft certification regulations. Since the Soloy Dual Pac engine propulsion drive system is part of the engine, the changes to part 23 of the FAR, which were published as a notice of proposed rulemaking (NPRM), ''Small Airplane Airworthiness Review Program Notice No. 3,'' in the Federal Register on October 3, 1990 (55 FR 40598); and § 33.87 of the FAR (amended through Amendment 33–5), will be used as a basis for special conditions intended to establish standards to address the design, function, and endurance testing of the gearbox. Section 33.87 regulations have been included in order to establish a comprehensive standards to address the turbine interface with the gearbox.

Type Certification Basis

Under the provisions of § 21.101 of the FAR, Soloy Corporation, must show that the Soloy Dual Pac engine meets the applicable provisions of the regulations incorporated by reference in Type Certificate No. E4EA, or the requirements of the applicable regulations in effect on the date of the application. The regulations incorporated by reference in the type certificate are commonly referred to as the ''original type certification basis.'' The regulations incorporated by reference in Type Certificate No. E4EA are as follows:

(a) FAR § 21.29, Issue of Type Certificate: Import Products.

(b) Civil Air Regulations (CAR) part 10, Certification and Approval of Import Aircraft and Related Products, dated March 28, 1955.

(c) FAR part 33, Airworthiness Standards: Aircraft Engines, effective February 1, 1965, as amended by Amendments 33–1 through 33–5 inclusive.

If the regulations incorporated by reference do not provide adequate standards with respect to the change, the applicant must comply with the regulations in effect on the date of application for the change that the FAA finds necessary to provide a level of safety equal to that established by the regulations incorporated by reference. Due to the potential applications of the Soloy Dual Pac engine, the FAA has determined that it must also be shown to comply with part 33 of the FAR, effective February 1, 1965, as amended by Amendment 33–1 through 33–5 inclusive, plus the following sections:

(a) Section 33.7, Amendment 33–12, Engine ratings and operating limitations.

(b) Section 33.67, Amendment 33–10, Fuel system.

(c) Section 33.68, Amendment 33–10, Induction system icing.

(d) Section 33.96, Amendment 33–11, Engine test in auxiliary power unit mode.

(e) Section 21.115(a), Applicable requirements.

In addition, compliance must be shown with part 34 of the FAR (Fuel Venting and Exhaust Emission Requirements for Turbine Engine Powered Airplanes); these special conditions contained herein on safety analysis, gearbox design, functioning, and endurance testing, and uncontained engine failure; as well as any applicable equivalent safety findings and any applicable exemptions.

The Administrator finds that the applicable airworthiness regulations in part 33, as amended, do not contain adequate or appropriate safety standards for the Soloy Dual Pac engine because of its novel or unusual design feature. Therefore, the Administrator prescribes special conditions under the provision of § 21.16 to establish a level of safety equivalent to that established in the regulations.

Special conditions, as appropriate, are issued in accordance with § 11.49 of the FAR after public notice and opportunity for comment, as required by §§ 11.28 and 11.29(b), and become part of the type certification basis in accordance with § 21.101(b)(2).

Discussion of Comments

Interested persons have been afforded the opportunity to participate in the making of these special conditions. One comment were received supporting the additional safety standards for the Soloy Dual Pac engine in the notice of proposed special conditions as published.

The FAA has gained a better technical understanding of the Soloy Dual Pac engine design since the notice of proposed special conditions were published in the Federal Register.

One of the critical systems of the Soloy Dual Pac engine is the single propeller. Paragraph(c)(1)(iv) was developed to ensure that a loss of oil pressure to the propeller governing system or the propeller shaft lubrication would not result in imminent loss of propeller speed or control. The zero oil pressure test as published in the notice of proposed special conditions does not adequately address these concerns. The blade pitch control system of the Soloy Dual Pac engine propeller installation is expected to contain a fail safe setting that is not equivalent to the 100 percent output speed required in the notice of proposed special conditions. When the propeller governor looses oil pressure, it will automatically revert to a predetermined mechanical limit, a so called ''get home'' pitch and speed. In addition, the 15 minute requirement (the notice of proposed special conditions stated ''15 seconds,'' however this was a typographical error) is not adequate for the type of aircraft installations where the Soloy Dual Pac is expected to be used. These airplanes, operating under part 121 of the FAR, will be allowed to operate over routes that contain a point up to one hour flying time from an adequate airport. The test of less than one hour of continued safe operation would not fulfill the intent of the paragraph (c)(1)(iv). The FAA has determined that paragraph (c)(1)(iv) as proposed, which set forth requirements for a zero oil pressure test of the gearbox, does not address the intent of this paragraph and therefore it is modified in these final special conditions. The revised test requirements in the final special conditions address more accurately the airplane failure scenario intended to be evaluated. However, the demonstrated torque and rotational speed must be included in the instruction manual for installing and operating the engine required in § 33.5 of the FAR.

Conclusion

This action affects only certain novel or unusual design features on one model engine configuration. It is not a rule of general applicability, and affects only the manufacturer who applied to the FAA for approval of these features on the engine.

List of Subjects in 14 CFR Part 33

Air transportation, Aircraft, Aviation safety, Safety.

The authority citation for part 33 continues to read as follows:

Authority: 49 U.S.C. 106(g); 40113, 44701, 44702, 44704

The Special Conditions

Accordingly, pursuant to the authority delegated to me by the Administrator, the following special conditions are issued as part of the type certification basis for the Soloy Corporation, Soloy Dual Pac engine:

(a) *Safety Analysis.*

It must be shown by analysis that any probable malfunction, or any probable single or multiple failure, or any probable improper operation of the Soloy Dual Pac engine will not cause the Soloy Dual Pac engine to—

(1) Catch fire;

(2) Burst (release hazardous fragments through the engine case);

(3) Generate loads greater than those ultimate loads specified in § 33.23(a);

(4) Lose the capability of being shut down; or

(5) Lose the capability of providing controllable 50 percent of rated power.

(b) *Uncontained Engine Failure.* Design precautions must be taken to minimize the damage to one PWC PT6 engine, in the event of uncontained engine failure of the other PWC Model PT6 engine, in order for the unfailed engine to be capable of continued torque production after such a failure.

(c) *Gearbox Design, Functioning, and Endurance Testing.*

(1) *Propulsion Drive System Design.* Propulsion drive systems, as defined in paragraph (c)(1)(i), must meet the requirements as set forth in paragraphs (c) (1) through (6).

(i) The propulsion drive system includes all parts necessary to transmit power from the engines to the propeller shaft. This includes couplings, universal joints, drive shafts, supporting bearings for shafts, brake assemblies, clutches, gearboxes, transmissions, any attached accessory pads or drives, and any cooling fans that are attached to, or mounted on, the propulsion drive system.

(ii) Each propulsion drive system, powered by more than one engine, must be arranged so that the propeller shaft and its control will continue to be powered by the remaining engine(s) if any engine fails.

(iii) Each multiengined propulsion drive system must incorporate a device to automatically disengage any engine from the propeller shaft, if that engine fails.

(iv) The oil for components of the propulsion drive system that require continuous lubrication must be sufficiently independent of the lubrication systems of the engine(s) to ensure operation with any engine inoperative. The propulsion drive system must be able to continue safe operation, although not necessarily without damage, at a torque and rotational speed prescribed by the applicant which is determined to be the most critical of the anticipated flight conditions. The drive system shall operate at this condition for at least one hour after perception by the flight crew of the lubrication system failure or loss of lubricant. The demonstrated torque and rotational speed must be included in the instructional manual for installing and operating the engine required in § 33.5 of the Federal Aviation Regulations (FAR).

(v) Torque limiting means must be provided on all accessory drives that are located on the propulsion drive system, in order to prevent the torque limits established for those drives from being exceeded.

(vi) There must be means to provide continued propulsion system control and operation, following the failure of an engine to transmission drive shaft.

(vii) In addition to the propulsion drive system complying with the requirements of paragraph (c)(1)(iii), the propulsion drive system, powered by more than one engine, must be designed so that torque to the propeller shaft is not interrupted after failure of any engine or element in the propeller shaft drive system; and examined in detail to determine all components and their failure modes that would be vital to continued control and operation of the propulsion drive system.

(viii) For each component and its failure modes identified by this examination, it must be shown by appropriate test that such a failure is not likely to occur in the system component's service life established by these tests; or that the system is designed so continued control and operation can be accomplished after occurrence of the failure.

(2) *Propulsion Drive System Limitations.* The propulsion drive system limitations must be established so that they do not exceed the corresponding limits approved for the engine, propeller shaft, and drive system components.

(i) For the Soloy Dual Pac engine, takeoff power must be limited by—

(A) The powerplant maximum rotational speed for takeoff power, and the maximum rotational propeller shaft speed may not be greater than the values determined by the propulsion drive system type design, or the maximum value shown during type tests.

(B) The time limit for the use of power, gas temperature, and speed corresponding to the limitations established in paragraph (i) of this section.

(C) The powerplant maximum allowable gas temperature at maximum allowable power or torque for each engine, considering the power input limitations of the transmission with all engines operating; and

(D) The powerplant maximum allowable gas temperature at maximum allowable or torque of each engine, considering the power input limitations of the transmission with one engine inoperative.

(ii) For the Soloy Dual Pac engine, continuous power must be limited by—

(A) The powerplant maximum rotational speed for continuous power. The maximum rotational propeller shaft speed may not be greater than the values determined by the propulsion drive system type design maximum value shown during type tests.

(B) The powerplant maximum allowable gas temperature of continuous power and the maximum allowable power or torque for each engine, considering the power input limitations of the transmission with both engines operating; and

(C) Powerplant maximum allowable gas temperature at maximum allowable power or torque of each engine, considering the power input limitations of the transmission with one engine inoperative.

(3) *Propulsion Drive System Instruments.* Connections for the following instruments must be provided for any gearbox or transmission:

(i) An oil pressure warning device for each pressure-lubricated gearbox to indicate when the oil pressure falls below a safe value;

(ii) A low oil quantity warning indicator for each gear box, if lubricant is self-contained;

(iii) An oil temperature warning device to indicate unsafe oil temperatures in each gearbox;

(iv) A tachometer for each propeller shaft;

(v) A torquemeter for each transmission driving a propeller shaft; and

(vi) A chip detecting and indicating system for each gearbox.

(4) *Propulsion Drive System Endurance Tests.* Each part tested, as prescribed in this section, must be in a serviceable condition at the end of the tests. No intervening disassembly that might affect these results may be conducted.

(i) *Endurance tests; general.* The propulsion system, as defined in paragraph (c)(1) must be tested as prescribed in paragraphs (c)(4)(ii) through (c)(4)(ix), for at least 200 hours plus the time required to meet paragraph (c)(4)(ix). For the 200-hour portion, these tests must be conducted as follows:

(A) Twenty each, ten-hour test cycles consisting of the test times and procedures in paragraphs (c)(4)(ii) through (c)(4)(viii); and

(B) The test torque must be determined by actual powerplant limitations.

(ii) *Endurance tests; takeoff torque run.* The takeoff torque run endurance test must be conducted as follows:

(A) The takeoff torque run must consist of a one-hour run on the engine(s) at the torque corresponding to takeoff power, but with the engine power setting alternately cycled every five minutes to as low an engine idle speed as practicable.

(B) Deceleration and acceleration of the engines and/or of individual engines and drive system must be performed at the maximum rate. (This corresponds to a one-second power setting change from idle to takeoff setting, and one second from takeoff setting to idle.)

(C) The time duration of all engines at takeoff power setting must total one hour and does not include the time required to go from takeoff to idle and back to take off speed.

(iii) *Endurance tests; maximum continuous run.* Three hours of continuous operation, at the torque corresponding to maximum continuous power and speed, must be conducted.

(iv) *Endurance tests; 90 percent of maximum continuous run.* One hour of continuous operation, at the torque corresponding to 90 percent of maximum continuous power, must be conducted at maximum continuous rotational propeller shaft speed.

(v) *Endurance tests; 80 percent of maximum continuous run.* One hour of continuous operation, at the torque corresponding to 80 percent of maximum power, must be conducted at the minimum rotational propeller shaft speed intended for this power.

(vi) *Endurance tests; 60 percent of maximum continuous run.* Two hours of continuous operation, at the torque corresponding to 60 percent of maximum continuous power, must be conducted at the minimum rotational propeller shaft speed intended for this power.

(vii) *Endurance tests; engine malfunctioning run.* It must be determined whether malfunctioning of components, such as the engine fuel or ignition systems, or unequal engine power can cause dynamic conditions detrimental to the drive system. If so, a suitable number of hours of operation must be accomplished under those conditions, one hour of which must be included in each cycle, and the remaining hours of which must be accomplished at the end of 20 cycles. This testing is to be equally divided between the following four conditions: (1) engine #1 ''ON''/engine #2 ''IDLE''; (2) engine #1''ON''/engine #2 ''OFF''; (3) engine #1 ''IDLE''/engine #2 ''ON''; (4) engine #1 ''OFF''/engine #2 ''ON''. If no detrimental conditions results, an additional hour of operation in compliance with paragraph (ii) of this section must be conducted.

(viii) *Endurance tests; overspeed run.* One hour of continuous operation must be conducted at the torque corresponding to maximum continuous power, and at 110 percent of rated maximum continuous rotational propeller shaft speed. if the overspeed is limited to less than 110 percent of maximum continuous speed by the speed and torque limiting devices, the speed used must be the highest speed allowable, assuming that speed and torque limiting devices, if any, function properly.

(ix) *Endurance tests; one-engine-out application.* A total of 160 full differential power applications must be made at takeoff torque and RPM. If, during these tests, it is found that a critical dynamic condition exists, an investigative assessment to determine the cause shall be performed throughout the torque/speed range. In each of the 160 engine power setting cycles (160 per engine drive branch) a full differential power application must be performed. In each cycle, the transition from clutch engagement to disengagement must occur at the critical condition for clutch and shaft wear.

(5) *Additional Propulsion Drive System Tests.* Additional dynamic, endurance, and operational test and vibratory investigations must be performed to determine that the drive mechanism is safe. The following additional tests and conditions apply:

(i) If the torque output of all engines to the transmission can exceed the highest engine or transmission torque limit, the following tests must be conducted. Under conditions associated with all engines operating, apply 200 cycles to the drive system for 10 seconds each of a torque that is at least equal to the lesser of—

(A) The maximum torque used in complying with paragraph (4)(ii) plus 10 percent; or

(B) The maximum torque attainable under normal operating conditions, assuming that any torque limiting devices function properly.

(ii) With each engine alternately inoperative, apply to the remaining transmission inputs the maximum transient torque attainable under normal operating condition, assuming that any torque limiting devices function properly. Each transmission input must be tested at this maximum torque for at least 15 minutes.

(iii) After completion of the 200 hour endurance test and without intervening major disassembly, the drive system must be subjected to 50 overspeed runs, each 30±3 seconds in duration, at a speed of at least 120 percent of maximum continuous speed, or other maximum overspeed that is likely to occur, plus a margin of speed approved by the Administrator for that overspeed condition. These runs must be conducted as follows:

(A) Overspeed runs must be alternated with stabilizing runs from 1 to 5 minutes duration, each 60 to 80 percent of maximum continuous speed.

(B) Acceleration and deceleration must be accomplished in a period no longer than 10 seconds, and the time for changing speeds may not be deducted from the specified time for the overspeed runs.

(iv) Each part tested, as prescribed in this section, must be in serviceable condition at the end of the tests. No intervening disassembly that might affect test results may be conducted.

(v) If drive shaft couplings are used and shaft misalignment or deflections are probable, loads must be determined in establishing the installation limits affecting misalignment. These loads must be combined to show adequate fatigue life.

(vi) The vibration test specified in § 33.83 must be applied to engine-furnished components of the propulsion drive system. The test must include the gear case and each component in the combining gear box whose failure due to vibration could cause unsafe operation of the engine.

(6) *Propulsion Drive System Shafting Critical Speed.* The critical speeds of any shafting must be determined by test, except that analytical methods may be used if reliable methods of analysis are available for the particular design.

(i) If any critical speed lies within, or close to, the operating ranges for idling and power on conditions, the stresses occurring at that speed must be within design limits. This must be shown by tests.

(ii) If analytical methods are used and show that no critical speed lies within the permissible operating ranges, the margins between the calculated critical speeds and the limits of the allowable operating ranges must be adequate to allow for possible variations between the computed and actual values.

Issued in Burlington, Massachusetts, on February 7, 1997.

James C. Jones,

Acting Manager, Engine and Propeller Directorate, Aircraft Certification Service.

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