Final and approved - include this changed AC section with AC 29-2C. It will be incorporated into the next published change or revision to AC 29-2.

AC 29.927. § 29.927 (Amendment 29-13) ADDITIONAL TESTS.

a. Section 29.927(a):

(1) Explanation. This paragraph is authority to require any special tests or investigations to establish that the rotor drive system is safe.

(2) Procedures. The certification engineer should review the design of the rotor drive system and its installation and intended operation for features or conditions that may not be adequately qualified in the tests prescribed by this Part. Additional qualification test programs should be developed and accomplished to ensure safe operation of the system. Items of interest would include poorly defined load paths associated with redundant design features, flight deflections of structure, mounting arrangements which may not be properly qualified by ground tests, and special or unusual operating procedures which are anticipated by the applicant.

b. Section 29.927(b):

(1) Explanation. This paragraph prescribes testing to qualify the rotor drive system for the power excursions to be expected with governor-controlled engines wherein the engine power changes automatically to maintain rotorspeed at preselected values. At high collective flight control displacements, the normal rotor speed droop will result in governor-controlled engines automatically accelerating to maximum fuel flow or to any other power, speed, temperature, or torque limiting device, regardless of crew action or artificially established limitations reflected by instrument markings. This high power condition can occur typically during a normal landing when the crew applies high collective to cushion ground contact or, for multiengine rotorcraft, during any flight regime when an engine fails and the corresponding loss of power results in drooping the rotor speed. Special tests are prescribed by this section to provide assurance that the rotor drive system can safely sustain these conditions. The tests of this section should be conducted without intervening disassembly, and all rotor drive system components should be in serviceable condition after the test. It is permissible but not required that these tests be performed on the same specimen of the rotor drive system used to show compliance with § 29.923.

(2) Procedures. These tests should be conducted on a ground-test rotorcraft conformed to the type design configuration similar to that required for endurance testing under § 29.923. Cyclic and collective control may be set to simulate vertical lift and antitorque control set and/or adjusted to react to main rotor torque. Rotation speed should be maximum normal for the test condition; i.e., for the all-engines test under § 29.927(b)(1), use the maximum RPM for

takeoff power. For the one-engine-inoperative (OEI) test of § 29.927(b)(2), RPM droop, if any, that would occur in service, may be allowed. Since the OEI test of § 29.927(b)(2) usually requires the remaining engine(s) to produce power not usually available under normal atmospheric conditions, some supplemental method, such as refrigerating and/or ramming inlet air, or overfueling the engine, may be required. Alternatively, bench testing (transmission test rig) of the rotor drive system (using only the components subject to the higher OEI power, if desired) may be appropriate providing close simulation of the rotor drive system installation environment is achieved. Overtesting, to compensate for inadequacies in the bench test setup may be negotiated with the FAA/AUTHORITY approval office. Note that compliance with § 29.903(b) requires that the remaining engine(s) be capable of continued safe operation under the same conditions as dictated by this test. The engine manufacturer may have already conducted tests adequate to substantiate this requirement. If not, his assistance in testing and the subsequent serviceability finding is imperative.

c. Section 29.927(c):

(1) Explanation.

(i) This section prescribes a test to demonstrate that any failure resulting in the loss of lubrication pressure to the rotor drive primary oil system will not impair the capability of the rotorcraft to operate under autorotative conditions for 15 minutes.

(ii) The regulation is intended to apply to pressurized lubrication systems and has not been applied to splash lubricated gearboxes since historically their design has not been as critical or complex when compared to pressurized systems. The likelihood of loss of lubrication is significantly greater for transmissions that use pressure lubrication and external cooling. This is due to the increased complexity of the lubrication system and the external components that circulate oil outside the gearbox. A pressure lubrication system is more commonly used in the rotorcraft's main transmission but may also be used in auxiliary transmissions or gearboxes.

(iii) The lubricating system has two primary functions. The first is to provide lubricating oil to contacting or rubbing surfaces and thus reduce friction losses. The second is to dissipate heat energy generated by friction of meshing gears and bearings, thus maintaining surface and material temperature. Accordingly, a loss of lubrication leads to increased friction between components and increased component surface temperatures. With increased component surface temperatures, component surface hardness can be lost, resulting in the inability of the component to carry or transmit loads. Thermal expansion in transmission components can eventually lead to the mechanical failure of bearings, journals, gears, shafts, and clutches that are subjected to high loads

and rotational speeds. A loss of lubrication may result from internal and external failures. Failures include, but are not limited to, oil lines, fittings, seal plugs, sealing gaskets, valves, pumps, oil filters, oil coolers, accessory pads, etc. A leak caused by a crack in the transmission outer case need not be considered as a source of a loss of lubrication provided the outer case has been structurally substantiated to satisfy the requirements of §§ 29.307, 29.923(m), and 29.571.

(2) Procedures. Conventionally, a bench test (transmission test rig) is used to demonstrate compliance with this rule. Since this is essentially a durability test of the transmission to operate with residual oil, typically the worst case failure (i.e., the undrainable oil or the oil remaining after a severe pressure leak, whichever results in a greater loss of oil in the transmission's normal lubrication system) is used as a critical entry point for the test. The transmission should be stabilized at the torque associated with maximum continuous power (reacted as appropriate at main mast and tail rotor output quills) at a normal main rotor speed, oil temperature that is at the highest limit for continuous operation, and oil pressure that is within the normal operating range. A vertical load should be applied at the mast, equal to the gross weight of the rotorcraft at 1g. Once the transmission oil temperature is stabilized, simulate the worst case failure in the normal use lubrication system. Upon illumination of the low oil pressure warning device (required by § 29.1305), reduce input torque to simulate an autorotation and continue transmission operation for 15 minutes. To complete the test, apply an input torque to the transmission for approximately 10 seconds to simulate a minimum power landing. A successful demonstration may involve limited damage to the transmission, provided it is determined that the autorotative capabilities of the rotorcraft were not significantly impaired.

d. Section 29.927(d):

(1) Explanation. This test is intended to demonstrate that overspeed conditions which may result from control failure or control misapplication will not incur damage to the rotor drive system. Specific conditions for conducting the test are provided in § 29.927(d)(1), (d)(2), and (d)(3).

(2) Procedures. The test may be conducted on a rotorcraft configured for the endurance tests prescribed by § 29.923. Turbine engines involved in the test may require fuel control rerigging or operation on the manual fuel control system, if available, to achieve test requirements.

Note: Some equivalent safety findings have been issued based on limiting the test speed to that permitted by an independent, reliable overspeed trip device, thus avoiding permanent damage to yokes, engines, etc., involved but not subject to evaluation under this rule.

(3) With collective control set for minimum rotor pitch for smooth operation, the cyclic control positioned for vertical lift, and the antitorque control

set in flat pitch, add power to achieve 120 percent of maximum continuous speed and hold this condition for 30 seconds. Deceleration and operation between overspeed runs should be as described in the rule. Acceleration and deceleration must be at maximum rates available to the configuration.

e. Section 29.927(e):

(1) Explanation. This paragraph sets forth conditions to be normally employed during the overtorque and overspeed tests of this section and authorizes certain exceptions with criteria for justification.

(2) Procedures. None.

AC 29.927A. § 29.927 (Amendment 29-26) ADDITIONAL TESTS.

a. Section 29.927(c):

(1) Explanation.

(i) Amendment 29-26 revised the rotor drive system loss of lubrication test requirements for Category A rotorcraft in § 29.927(c). This requires testing to show that any failures that result in a loss of lubrication in any normal use lubrication system, unless the failures are extremely remote, will not prevent continued safe flight for at least 30 minutes after the flight crew recognizes the loss of lubricant failure.

(ii) The introductory phrase to this amendment to the regulation, “unless such failures are extremely remote” has caused confusion. The NPRM did not contain this expression and the only change documented in the preamble to the final rule (53 FR 34204) explains that the final rule was revised in response to a public comment that the proposed regulation could be interpreted to “preclude credit for auxiliary lubrication systems or to require consideration of lubricant failures to self-lubricated bearings.” This was not intended and the final rule was “revised to eliminate this possible ambiguity.” The phrase, “unless such failures are extremely remote,” was introduced to resolve the public comment to convey that the applicant does not have to consider failures that may exist in the auxiliary lubrication system prior to performing the loss of lubrication testing. Under the current regulation, the extremely remote language in the final rule means that testing to demonstrate at least 30 minutes continued flight capability (for Category A), following loss of lubrication in the normal lubrication system, is not required if the failures leading to that loss of lubrication condition are determined to be extremely remote. While this compliance approach is allowed, it may not be achievable due, in part, to the unforeseen variables and complexity associated with predicting potential lubrication failure modes and their associated criticality and frequency of occurrence. This includes considering lubrication failures that may result from improper transmission maintenance and servicing.

The expected compliance approach has been to assume a failure in the normal lubrication system leading to rapid loss of lubrication and to rely on an auxiliary lubrication system or the robustness of the transmission components to accomplish at least 30 minutes of operation (for Category A) at the prescribed conditions. With this approach, the normal and auxiliary systems must be independent in order to preclude common loss of lubrication failure points and possible cross contamination. Compliance with § 29.1309 would only apply to any electrical and software design aspects of the normal and auxiliary lubrication systems. The auxiliary lubrication system must also be designed, constructed, and functionally tested to show that it can perform its intended function.

(iii) The regulation is intended to apply to pressurized lubrication systems and has not been applied to splash lubricated gearboxes since historically their design has not been as critical or complex when compared to pressurized systems. The likelihood of loss of lubrication is significantly greater for transmissions that use pressure lubrication and external cooling. This is due to the increased complexity of the lubrication system and the external components that circulate oil outside the gearbox. A pressure lubrication system is more commonly used in the rotorcraft's main transmission but may also be used in auxiliary transmissions or gearboxes.

(iv) The lubricating system has two primary functions. The first is to provide lubricating oil to contacting or rubbing surfaces and thus reduce friction losses. The second is to dissipate heat energy generated by friction of meshing gears and bearings, thus maintaining surface and material temperature. Accordingly, a loss of lubrication leads to increased friction between components and increased component surface temperatures. With increased component surface temperatures, component surface hardness can be lost resulting in the inability of the component to carry or transmit loads. Thermal expansion in transmission components can eventually lead to the mechanical failure of bearings, journals, gears, shafts, and clutches that are subjected to high loads and rotational speeds. A loss of lubrication may result from internal and external failures. Failures include, but are not limited to, oil lines, fittings, seal plugs, sealing gaskets, valves, pumps, oil filters, oil coolers, accessory pads, etc. A leak caused by a crack in the transmission outer case need not be considered as a source of a loss of lubrication provided the outer case has been structurally substantiated to satisfy the requirements of §§ 29.307, 29.923(m), and 29.571.

(v) The intent of the rule change for Category A rotorcraft was to assure that these rotorcraft have significant continued flight capability after the loss of lubricant to any single transmission in order to optimize eventual landing opportunities. Extending the bench testing beyond 30 minutes, although not required, is considered highly desirable. Accomplishing this would further improve the capability of the rotorcraft to reach a suitable landing location in order to improve occupant safety when operating in remote geographic areas that include harsh environmental conditions. Indefinite flight with a lubrication

system failure is not expected. However, it may be acceptable to include a time interval in the emergency procedures. That time interval should be reduced sufficiently when compared to the bench test demonstration to allow for an adequate safety margin.

(2) Procedures.

(i) Section 29.927(c)(1) prescribes a test to demonstrate that the effects of a loss of lubrication will not prevent continued safe powered operation for category A rotorcraft for at least 30 minutes after illumination of the low oil pressure warning device (required by § 29.1305). For category B rotorcraft, § 29.927(c)(2) prescribes the tests for safe operation under autorotative conditions must continue for at least 15 minutes.

(ii) An acceptable means of demonstrating compliance with this rule is through the use of a bench test (transmission test rig). Since this is essentially a durability test of the transmission to operate with residual oil, typically the worst case failure (i.e., the undrainable oil or the oil remaining after a severe pressure leak, whichever results in a greater loss of oil in the transmission's normal use lubrication system) is used as a critical entry point for the test; see paragraph a.(2)(iii).

(iii) The transmission should be stabilized at the torque associated with maximum continuous power (reacted as appropriate at the main mast and tail rotor output quills) at a normal main rotor mast speed, oil temperature that is at the highest limit for continuous operation, and oil pressure that is within the normal operating range. A vertical load should be applied at the mast, equal to the gross weight of the rotorcraft at 1g. Once the transmission oil temperature is stabilized, simulate the worst case failure in the normal use lubrication system. Upon illumination of the low oil pressure warning device (required by § 29.1305), reduce the input torque for category A rotorcraft to the minimum torque necessary to sustain flight and continue the test for at least 30 minutes at the maximum gross weight and the most efficient flight conditions. To complete the test, apply an input torque to the transmission for approximately 25 seconds to simulate an autorotation. The last 10 seconds (of the 25 seconds) should be at the torque required for a minimum power landing. A successful demonstration may involve limited damage to the transmission, provided it is determined that the autorotative capabilities of the rotorcraft were not significantly impaired. For category B rotorcraft, upon illumination of the low oil pressure warning device, reduce the input torque to simulate an autorotation and continue transmission operation for 15 minutes. To complete the test, apply an input torque to the transmission for approximately 10 seconds to simulate a minimum power landing. A successful demonstration may involve limited damage to the transmission provided it is determined that the autorotative capabilities of the rotorcraft were not significantly impaired. If compliance with category A requirements is demonstrated, category B requirements will have been met.

b. Section 29.927(d):

(1) Explanation. The revision to paragraph (d) includes a requirement to demonstrate that overspeed conditions, which may result from an engine control device failure or other event such as a control misapplication, will not result in damage to the rotor drive system.

(2) Procedures. The overspeed endurance cycle and overspeed conditions to be demonstrated are defined in this section. The test may be conducted on a rotorcraft configured for the endurance tests prescribed by § 29.923. Turbine engines involved in the test may require fuel control re-rigging or operation on a manual fuel control system to meet test requirements. Fifty overspeed runs of 30 ±3 seconds must be run on the rotor drive system. The overspeed runs must be alternated with stabilizing runs of 1 to 5 minutes duration each at 60 to 80 percent of maximum continuous speed.

(i) The maximum speed to be demonstrated during the power on overspeed test is:

(A) The higher of:

(1) The speed to be expected from an engine control device failure; or,

(2) 105 percent of the maximum rotational speed to be expected in service, including transients.

(B) The maximum speed allowed by a speed limiting device if the device is installed independent of the engine controls and is shown to be reliable.

(ii) From the stabilizing run condition, increase power to achieve the maximum speed established from (i) above. Set the collective for minimum blade pitch for smooth operation. The cyclic control should be positioned for vertical lift, and the anti-torque control should be set in flat pitch. Hold this condition for 30 seconds, then decelerate to the stabilizing run condition.

(iii) The acceleration and deceleration described above should be accomplished in 10 seconds or less except where it can be shown that the certified engine acceleration or deceleration rate exceeds 10 seconds. The time required for acceleration and deceleration may not be deducted from the 30 second overspeed period.

Note: Some equivalent safety findings have been issued based upon limiting the test speed to that permitted by an independent, reliable overspeed trip

device. This has been done to avoid permanent damage to rotors, yokes, engines, etc., which are involved, but not under evaluation by this test.

c. Section 29.927(f):

(1) Explanation. Amendment 29-26 also added a new paragraph (f), which requires that the overtorque, lubrication system failure, and overspeed tests required by § 29.927(b), (c), and (d), respectively, be conducted without intervening disassembly during the individual test. After each test, a teardown inspection is performed, and except for the components used in the lubrication system failure test, the components are required to be in serviceable (return to service) condition.

(2) Procedures. None.