U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject:	CERTIFICATION OF TRANSPORT CATEGORY ROTORCRAFT	**Date:**	9/30/2008	**AC No:**	29-2C
		Initiated by:	ASW-110	**Change:**	3

1. PURPOSE.

a. This Advisory Circular (AC) publishes needed changes to the existing AC material as a result of a safety-focused study.

b. This change revises existing material in 9 sections.

c. The change number and the date of the changed material are shown at the top of each page. The vertical lines in the right or left margin indicates the beginning and end of each change. Pages that have different page numbers, but no text changes, will retain the previous heading information.

d. This AC does not change regulatory requirements and does not authorize changes in, or deviations from, regulatory requirements. This AC establishes an acceptable means, but not the only means, of compliance. Since the guidance material presented in this AC is not regulatory, terms having a mandatory definition, such as "shall" and "must," etc., as used in this AC, apply either to the reiteration of a regulation itself, or to an applicant who chooses to follow a prescribed method of compliance without deviation.

2. PRINCIPAL CHANGES. Sections 29.571, 29.679, 29.695, 29.783, 29.901A, 29.917A, 29.1307, 29.1351, and 29.1431 are revised.

3. WEBSITE AVAILABILITY. To access this AC electronically, log on to http://www.airweb.faa.gov/rgl and then click on AC's.

AC 29-2C, Chg 3
PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
vii thru x	2/12/03 & 4/25/06	vii thru x	2/12/03, 4/25/06, & 9/30/08
xiii & xiv	2/12/03 & 4/25/06	xii thru xiv	9/30/08
C-93 thru C-96	9/30/99 & 2/12/03	C-93 thru C-96	2/12/03 & 9/30/08
D-41 thru D-44	9/30/99 & 4/25/06	D-41 thru D-44	9/30/08
D-47 & D-48	9/30/99	D-47 thru D-48	9/30/99 & 9/30/08
D-79 thru D-82	9/30/99	D-79 thru D-82	9/30/08
E-7 & E-8	9/30/99	E-7 & E-8	9/30/99 & 9/30/08
E-35 thru 38	9/30/99 & 4/25/06	E-35 thru E-48	9/30/99 & 9/30/08
F-11 & F-12	9/30/99 & 2/12/03	F-11 & F-12	9/30/08
F-65 & F-66	9/30/99	F-65 thru F-66.2	9/30/08
F-113 thru F-116	9/30/99	F-113 thru F-116	9/30/99 & 9/30/08

Signed by Scott A. Horn for

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SUBPART D - DESIGN AND CONSTRUCTION

Page No.

GENERAL

ROTORS

CONTROL SYSTEMS

SUBPART D - DESIGN AND CONSTRUCTION (continued)

Page No.

LANDING GEAR

FLOATS AND HULLS

PERSONNEL AND CARGO ACCOMMODATIONS

SUBPART D - DESIGN AND CONSTRUCTION (continued)

Page No.

PERSONNEL AND CARGO ACCOMMODATIONS(continued)

FIRE PROTECTION

EXTERNAL LOAD ATTACHING MEANS

MISCELLANEOUS (DESIGN AND CONSTRUCTION)

SUBPART E - POWERPLANT

GENERAL

SUBPART E - POWERPLANT (continued)

Page No.

GENERAL (continued)

ROTOR DRIVE SYSTEM

FUEL SYSTEM

SUBPART E - POWERPLANT (continued)

Page No.

POWERPLANT FIRE PROTECTION (continued)

SUBPART F - EQUIPMENT

GENERAL

INSTRUMENTS - INSTALLATION

ELECTRICAL SYSTEMS AND EQUIPMENT

SUBPART F - EQUIPMENT (continued)

Page No.

LIGHTS

SAFETY EQUIPMENT

MISCELLANEOUS EQUIPMENT

SUBPART G - OPERATING LIMITATIONS AND INFORMATION

OPERATING LIMITATIONS

(1) The rotorcraft support structure, structure-float attachments, and floats should be substantiated for rational limit and ultimate ditching loads.

(2) The most severe wave heights for which approval is desired are to be considered. A minimum of Sea State 4 condition wave heights should be considered (reference paragraph AC 29.801 (§ 29.801) for a description of Sea State 4 conditions).

(3) The landing structural design consideration should be based on water impact with a rotor lift of not more than two-thirds of the maximum design weight acting through the center of gravity under the following conditions:

(i) Forward velocities of 0 to 30 knots (or a reduced maximum forward velocity if it can be demonstrated that a lower maximum velocity would not be exceeded in a normal one-engine-out landing).

(ii) The rotorcraft pitch attitude that would reasonably be expected to occur in service. Autorotation flight tests or one-engine-inoperative flight tests, as applicable, should be used to confirm the attitude selected. This information should be included in the Type Inspection Report.

(iii) Likely roll and yaw attitudes.

(iv) Vertical descent velocity of 5 FPS or greater.

(4) Landing load factors and water load distribution may be determined by water drop tests or analysis based on tests.

(5) Auxiliary or emergency float loads should be determined by full immersion or the use of restoring moments required to react upsetting moments caused by sidewind, asymmetrical rotorcraft landing, water wave action, rotorcraft inertia, and probable structure damage and punctures considered under § 29.801. Auxiliary or emergency float loads may be determined by tests or analysis based on tests.

(6) Floats deployed after initial water contact are required to be substantiated by tests or analysis for the specified immersion loads (same as for (5) above and for the specified combined vertical and drag loads).

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SUBPART C - STRENGTH REQUIREMENTS

FATIGUE EVALUATION

AC 29.571. § 29.571 FATIGUE EVALUATION OF FLIGHT STRUCTURE.

a. Explanation. An evaluation is required to assure structural reliability of the rotorcraft in flight. This evaluation may take the form of either tests or analysis. During the certification process, fatigue testing is more effective than analysis alone in identifying and preventing cracking that may occur during service. Analysis used for substantiation should be validated by tests. AC 27 MG 11 contains background information and acceptable means of compliance with the requirements pertaining to the safe life methodology. A safe life may be assigned or the structure may be determined to be fail safe or a combination of these may be used. AC 29 MG 11 contains background information and acceptable means of compliance with the requirements pertaining to fatigue and flaw tolerance.

b. Procedures.

(1) The fatigue evaluation requires consideration of the following factors:

(i) Identification of the structure/components to be considered.

(ii) The stress during operating conditions.

(iii) The operating spectrum or frequency of occurrence.

(iv) Fatigue strength, and/or fatigue crack propagation characteristics, residual strength of the cracked structure.

(2) Since the design limits, e.g., rotor RPM (maximum and minimum), airspeed, and blade angles (thrust, weight, etc.) affect the fatigue life of the rotor system, it is necessary that flight conditions be conducted at limits that are appropriate for the particular rotorcraft and at the correct combination of these limits. It will be the responsibility of flight test personnel to determine that the flight strain program includes conditions of flight at the various combinations of rotor RPM, airspeed, thrust, etc., that will be representative of the limits used in service. The flight test personnel should assure that the severity of the maneuvers to be investigated is such that actual service use will not be more severe. Flight test verification may be achieved through:

(i) Flying a representative set of maneuvers with the applicant's pilot in the test aircraft at noncritical combinations of weight, CG, and speed. (An FAA/AUTHORITY letter for specific test authorization would ordinarily be required.)

(ii) Flying a representative set of maneuvers with the applicant's pilot in a similar (certified) model to assess and agree upon the required maneuvers, control deflections, and aircraft rates. The required maneuvers or conditions will be specified in the flight strain program plan.

(iii) Flying a chase aircraft which has a flight envelope appropriate to allow visual confirmation of the proposed and programmed flight maneuvers.

(iv) Observation of telemetered flight data to assure desired control deflections, rates, and aircraft attitudes.

(v) Some combinations of items b(2)(i) through b(2)(iv) above.

(3) Assessing the operation spectrum and the flight loads or strain measurement program will involve airframe, propulsion, and flight test personnel.

(4) Variation in the operating or loading spectrum among models, and variations in the spectrum for a particular model rotorcraft, should be evaluated. Figure AC 27 MG 11-7 contains typical flight load measurement program conditions to be investigated. An example of a twin turbine spectrum is presented in Figure AC 27 MG 11-9. The tables should be used only as a guide and should be modified as necessary for each particular rotorcraft design.

(5) The difference in loading spectrum for different models that may be anticipated is illustrated by comparing the percentage of time assigned to level flight conditions, specifically 0.8 V_H to 1.0 V_H for three different rotorcraft designs where V_H is the maximum airspeed at maximum continuous power in level flight. The first column applies to a single-piston-engine powered small rotorcraft used in utility operations. The second was obtained from data for a single-turbine-engine powered seven-place small business and utility rotorcraft. The third was obtained from data for a twin-engine-powered 13 passenger transport rotorcraft. It should be noted that the level flight percentage of occurrences shown in the table below for the turbine utility business and turbine transport rotorcraft are examples of a particular design. The high percentage of time shown in this flight regime could be unconservative for some designs, especially if the stresses under these design conditions produce an infinite fatigue life for the particular component. The fatigue spectrum percentage of occurrences may be modified according to the intended operation usage of the rotorcraft. However, a conservative application should be considered. This variation illustrates the "tailoring" of the loading spectrum for the type of rotorcraft and the anticipated usage.

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FIGURE AC 29.571-1

Comparison Percent of Time in Level Flight

Piston Utility		Turbine Utility Business		Twin Turbine Transport	
0.8 V_{NE}	25%	0.8 V_H	16%	0.8 V_H	15%
1.0 V_H	15%	0.9 V_H	21%	0.9 V_H	20%
1.0 V_{NE}	3%	1.0 V_H	24%	1.0 V_H	38%
Total	43%		61%		73%

This variation illustrates the "tailoring" of the loading spectrum for the type of rotorcraft and the anticipated usage.

(6) External cargo operations are a unique and demanding operation. A "logging" operator may use 50 maximum power applications per flight hour to move logs from a cutting site to a hauling site. Power is used to accelerate, decelerate, or hover prior to load release. Lifting loads over an obstruction or natural barrier is another example of very frequent high power applications for takeoff and for hovering over the release area. Similar types of operations require flight loads data to assess the effects on fatigue critical components.

(7) Frequently the applicant may request approval of a gross weight for an external cargo configuration that exceeds the standard configuration gross weight. The external cargo V_{NE} is typically significantly lower than the standard configuration V_{NE} possibly due to adverse effects on flight loads at the increased weight.

(8) The impact of the external cargo operation on standard configuration limits should be assessed to determine whether or not the component service lives will be affected. The assessment may be done by calculating an "external cargo configuration" service life for each critical component. The lowest service life obtained from standard configuration flight loads data and loading spectrum, or from external cargo configuration flight loads data and loading spectrum is generally the approved service life. This procedure avoids prorating the operating time between the two types of operations. This procedure is necessary since the regulatory maintenance and operating rules do not require recording time in service for the different types of operations.

(9) The applicant should plan to conduct a flight loads survey program for both a standard configuration and an external cargo configuration, if appropriate. This procedure will avoid delays associated with reinstallation and calibration of equipment.

AC 29.679. § 29.679 CONTROL SYSTEM LOCKS.

a. Explanation.

(1) Whenever a control system lock or locks are used, the standard requires design features to prevent flight or limit operation before flight begins with the lock engaged. Locks are not required by the standard.

(2) After flight begins, design features shall be used when needed to prevent possible lock engagement while the rotorcraft is in flight or ground operation.

(3) The standard applies to external control locks as well as internal locks.

b. Procedures.

(1) Locks that release or disengage automatically, as stated, may be used. Attention should be directed to reviewing possible means of lock engagement while in flight. Fault analysis of the system should be used to ensure possible failures are determined. Design features may be used or needed to preclude this event.

(2) Manually applied and released locks may be used. Design features of the locks must prevent engagement in flight also.

(3) Any "unmistakable" warning to prevent takeoff with a lock engaged should be easily discernable during day and night operations. It should be possible to apply the lock only in such a manner that the required warning is provided. Color, location, shape (identification), and accessibility of the device or its control and legibility of any device placards or markings are important considerations in the evaluation.

(4) During a "compliance inspection," and during TIA evaluations, the locks shall be evaluated to the standards. When a lock is not automatically disengaged, the operation of the rotorcraft should be limited. Unmistakable warning may be achieved as follows.

(i) Prevent sufficient power for takeoff.

(ii) The pilot shall be unable to move the collective control from the lowest pitch limit.

(iii) One or more aural devices that cannot be disengaged (turned off) until all locks are removed.

(5) The rotorcraft Instructions for Continued Airworthiness should include appropriate maintenance checks and procedures to be completed following modification (for example, via STC or field approval), maintenance, alignment, or adjustment that affects the flight control system locks.

AC 29.681. <u>§ 29.681 LIMIT LOAD STATIC TESTS</u>.

a. <u>Explanation</u>.

(1) The rule requires static tests of the control system in showing compliance with limit load requirements.

(2) The tests are specified to include each fitting, pulley, and bracket of the control system being tested and to include the "most severe loading."

(3) Also, the rule requires that compliance with bearing factors (reference § 29.623) be shown by individual tests or by analyses for control system joints subject to motion.

b. <u>Procedures</u>.

(1) Compliance with the requirements of this rule is obtained by static tests conducted on either a static test airframe or on a prototype flying ship. In either case, conformity of the control system and related airframe is necessary to validate the tests.

(2) The rotor blades or aerodynamic surfaces may be used to react pilot effort loads through the control system or they may be replaced with fixtures. If fixtures are used, they should be evaluated for geometric and stiffness effects to assure test validity.

(3) The loads to be applied during the limit load static tests are specified in §§ 29.395, 29.397, and 29.399. The loads are applicable to collective, cyclic, yaw, and rotor blade control systems as well as any other flight control systems provided by the design.

(4) Section 29.585(e) specifies bearing factors for control system joints subject to angular motion. These factors are 3.33 for push-pull systems and 2.0 for cable systems for joints with plain bearings. For joints with ball or roller bearings, use the manufacturer's ratings.

AC 29.683. <u>§ 29.683 OPERATION TESTS</u>.

a. <u>Explanation</u>. The rule requires that the control system be free from jamming, excessive friction, and excessive deflection. An operational test is required in which specified loads are applied at the pilot controls and carried through an operating control system.

b. <u>Procedures</u>.

(1) Compliance with the requirements of this rule is obtained by use of a test setup similar to that used for the limit load tests of § 29.681, except the load reactions at

the blades (or surfaces) must allow for movement of the blades (or surfaces) as the system is operated through its operating range.

(2) Fixtures are normally affixed to the surfaces (or replace the surfaces) to allow pulley arrangements which provide for movement under load. These fixtures should be evaluated to assure that system loads up to limit will be applied during the full range of operations of each system.

(3) Each flight control system should be operated through its entire range under a light load and under limit load. As the controls are being operated, the system should be checked for jamming, excessive friction, and excessive deflection. Excessive deflection includes deflection sufficient to contact other systems or structure. Also, if under these limit load conditions the components deflect, the deflection would be considered excessive if there is permanent deformation of any component or supporting structure. Also any deflection that results in an uncorrected condition when the load is released, e.g., if a bellcrank is forced off-center or over-center during load and does not return to the normal position after load release is excessive deflection. Floor panels, wall panels, and other access panels may have to be removed to permit visual checks of the entire control system. However, care should be taken when removing panels so that airframe structure is not weakened enough to deflect from its normal position when test loads are applied to the control system.

AC 29.685. § 29.685 (Amendment 29-12) CONTROL SYSTEM DETAILS.

a. Explanation. The rule requires that the control system be designed to prevent chafing, jamming, and interference from cargo, passengers, loose objects, or the freezing of moisture. Specifically, means are required in the cockpit to prevent the entry of foreign objects into places where they would jam the system, and means are required to prevent the slapping of cables or tubes against other parts. Specific design considerations to prevent binding and overloads within the control system are required such as--

(1) Assure pulley-cable combinations as specified in MIL-HDBK-5 are used unless inapplicable.

(2) Assure close fitting pulley guards are provided.

(3) Assure pulley-cable alignment sufficient to prevent excessive pulley flange loads is provided.

(4) Assure fairlead-cable alignment is within 3°.

(5) Assure no clevis pins are retained only by cotter pins.

(6) Assure turnbuckles do not bind other structures throughout the range of travel.

(7) Assure means for inspection of control system components are provided.

(8) Assure control system joints subject to angular motion incorporate special bearing factors, 3.33 for push-pull systems and 2.0 for cable systems.

(9) Assure that manufacturer's ratings for ball or roller bearing ratings are not exceeded.

b. Procedures.

(1) The geometry of the control system components and installations is the primary control to prevent chafing, jamming, and interference. The control system from cockpit to surface should be checked for clearances both unloaded and loaded. The control system should be checked under load during both the limit load static tests (reference § 29.681) and the operational tests of § 29.683. Location of guides or fairleads and pulleys may be used in cable systems to prevent chafing and interference with other structure. Generally, tubes should clear adjacent structure by location and design geometrical considerations. If supplemental means are provided to assure the tubes do not chafe or interfere, the means should be evaluated for possible jamming.

(2) Rubber (or other elastomeric) boots connected to both the cockpit control arm or shaft and to the floor are acceptable means to prevent the entry of foreign objects into underfloor areas where they may cause jamming of controls. Control systems should, in general, be routed around cargo compartments. If routing of the control system components is in or near cargo areas, the control system components should be protected by bulkheads, panels, or other enclosures which have sufficient strength and stiffness to prevent possible interference with the control system components when subjected to cargo loading and handling deflections.

(3) Control system details should be reviewed for possible moisture collection. Areas should drain free. Exposed or open control areas should drain free, and areas of possible freezing moisture collection should not accumulate ice that would cause a jam of the controls. Simulated or actual ice collection on the controls may be used to prove questionable features. The areas to be considered for moisture collection include both external and internal areas where moisture may accumulate by direct impingement of water, entrapment of water particles, or condensation of moisture.

(4) The latest revisions of MIL-HDBK-5 do not explicitly give approved pulley-cable combinations, but appropriate MIL specifications are given in Chapter 8.3 for use in determining pulley-cable combinations and ratings.

(5) Provide ratings, factors, and alignment as specified.

(6) Provide inspection means as specified.

(7) Provide close fitting pulley guards as specified.

(1) The rule requires an alternate system if a power boost or power-operated control system is used.

(2) The alternate system must, in the event of any single failure in the power portion of the system, or in the event of failure of all engines:

(i) Be immediately available.

(ii) Allow continued safe flight and landing.

(3) The alternate system may be:

(i) A duplicate power portion of the system; or

(ii) A manually operated mechanical system.

(4) The power portion of the system includes:

(i) The power source (such as hydraulic pumps); and

(ii) Items such as valves, lines, and actuator.

(5) The failure of mechanical parts (such as piston rods and links) must be considered unless their failure is extremely improbable.

(6) The jamming of power cylinders must be considered unless their jamming is considered extremely improbable.

c. Procedures. It is assumed in the following discussion that the power boost or power-operated control system being utilized is a typical aircraft hydraulic system.

(1) The rule requires, without regard to the probability of failure, an alternate system for the power portion of the system. The power portion of the system, by example in the rule, includes hydraulic pumps, valves, lines, and actuators. It has also been interpreted to include seals, servo valves, and fittings.

(2) If a duplicate power portion of the system is used to meet the requirements of the rule, the requirements may be met by providing a dual independent hydraulic system, including the reservoirs, hydraulic pumps, regulators, connecting tubing, hoses, servo valves, servo-valve cylinder, and power actuator housings. There must be no commonality in fluid-carrying components. A break in one system should not result in fluid loss in the remaining system.

(3) Dual actuators should be designed to assure that any single failure in the duplicated portion of the system, such as a cracked housing, broken interconnecting

input, or broken interconnecting output link, does not result in loss of total hydraulic system function.

(4) A manually operated mechanical system may be used as the alternate system to a single hydraulic system if, after the loss of the single hydraulic system, the pilot can control the rotorcraft without exceptional piloting skill and strength in any normal maneuver for a period of time as long as that required to effect a safe landing. The control forces should not exceed those specified in § 29.397 and flight characteristics should meet the requirements of §§ 29.141 (b) and (b)(3).

(5) The substantiation of the various system components should include consideration for operation in the normal and alternate system modes.

(6) The "extremely improbable" criteria noted in § 29.695(c) for failure of mechanical parts may be satisfied by performing component fatigue testing and establishing a service life through this technique.

(7) Fatigue substantiation of the control actuator is required under § 29.571 and should consider both the stresses imposed by flight loads and the stresses imposed by hydraulic pump pressure pulses. Flight loads factored in a suitably conservative manner may be an acceptable means to take into account both effects.

(8) The possibility of jamming of the power cylinder may be shown as "extremely remote" through a failure analysis that considers every possible system component failure such as, but not limited to, ruptured lines, pump failure, regulator failure, ruptured seals, clogged filters, jammed servo valves, broken interconnecting servo valve inputs, broken interconnecting output links, etc.

(9) Three acceptable means to meet the requirements of § 29.695(a)(2) could be as follows:

(i) Provide two transmission-driven hydraulic pumps, provided the pumps are driven by the transmission during all flight conditions including autorotation.

(ii) Use two electrically driven hydraulic pumps if electrical power is available to drive the pumps with all engines failed. If this approach is used, the battery must be capable of running both pumps plus all other required equipment necessary for continued safe flight.

(iii) Use a single transmission driven pump and an electrically driven pump.

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(2) Means are required for locking crew and external passenger doors to prevent their opening in flight due--

(i) To inadvertent operation; or

(ii) To mechanical failure.

(3) External doors are required to be openable from the inside or outside by simple and obvious means.

(4) Reasonable provisions to prevent jamming of external doors are required as specified and to assure that an "airstair door" is useable.

(5) The following visual indications of external doors being closed and locked are required:

(i) Direct visual inspection means by crewmembers of the locking mechanism of all external doors.

(ii) Visual means to signal to crewmembers "when normally used external doors are closed and fully locked."

(6) For certain outward opening doors, an auxiliary safety latching device is required "to prevent the door from opening when the primary latching mechanism fails." Suitable operating procedures to prevent this device from being used during takeoff and landing are required if the door cannot be opened from outside the rotorcraft (reference § 29.783(c)) with the device in place.

(7) If the door is a sliding door and intended to be opened and closed in flight, the sliding mechanism should positively attach the door to the airframe (e.g., sliding hinge) to minimize the likelihood of the door departing the aircraft in flight. Appropriate flight limitations should also be established to minimize any hazard while operating the door.

b. Procedures.

(1) Passenger doors should be located as far as possible from the auxiliary rotors. The doors may be hinged and door open stops may be provided to separate entering and egressing passengers from the auxiliary rotor blades. If necessary for the design, "appropriate instructions" should be provided for all passenger doors concerning entering and leaving the rotorcraft and safe use of each door relative to all rotors. These instructions should be obvious to a passenger using the door, contain large enough letters to be readily legible, and use letters or background colors associated with danger (i.e. orange or red).

(2) Means to prevent the opening of doors in flight.

(i) Means to prevent the opening of doors in flight due to inadvertent operation may be provided by recessing door handles to prevent their inadvertent operation by the normal movement of passengers about the cabin. If recessing the door handle is impractical, a cover may be provided which will prevent inadvertent operation of the handle, but the cover should be of such design that it does not obscure the door handle or its operating instructions. It must not unduly interfere with deliberate operation of the door handle by passenger or crew. Transparent or nonsolid covers, easily displaced by deliberate actions, have been used to prevent inadvertent door handle operation. Some rotorcraft designs meet this requirement by requiring that passengers wear their seat belts at all times during flight. This design requires that the "fasten seat belt" sign be on at all times the rotorcraft is in flight (for practical purposes, the "fasten seat belt" light is generally designed to be on when power is applied to the rotorcraft).

(ii) Means to prevent inadvertent door opening in flight due to "mechanical failure" is most efficiently provided by multiple door latches and multiple load path door locking mechanisms so that the door will remain locked after a single failure. Care should be taken in the design of multiple load path latches and mechanisms to assure independence of all failures and to consider the effort of deflections after failures (if a failure allows deflections into the airstream sufficient to increase aerodynamic loads, the increase in loads should be accounted for; if a failure allows significant movement of latching components, the deflections should be accurately accounted for to assure that disengagement of nonfailed latches does not occur).

(3) The means to open normally used external doors is required to be simple (such as a rotating handle) and to be accessible from the inside or the outside. To prevent the inadvertent use of emergency exits (separate from normal entry doors) for routine entry and exit with the resulting "wear and tear," the normally used doors for entry and exits should be equipped with operating handles and instructions distinctly different from those of the emergency exits. Obviously, the above does not apply to normally used exits which are also the primary (or only) emergency exits.

(4) Reasonable provisions to prevent jamming of external doors include the following:

(i) Design features of doors which are insensitive to large fuselage deflections for door operation.

(ii) Provision of clearance between door and door frame latching devices sufficient to allow some relative deflection between the door and door frame and still allow door operation. The relative deflections may be determined by static test or by an analysis approved by the FAA/AUTHORITY.

(iii) Sliding doors are frequently used in transport rotorcraft for versatility and utility reasons. If sliding doors are used, one of the following features of design may be required to assure that the requirements of § 29.783(d) are met:

(A) The sliding door(s) must be provided with jettison features which allow release of the door(s) from the tracks (to preclude jamming). The emergency release is generally separate and distinct from the normal door handle.

(B) Separate emergency exits of appropriate size and number may be installed in the sliding door(s).

(C) Separate emergency exits of appropriate size and number may be installed in addition to the sliding door(s).

(iv) Whether or not the sliding door is qualified as an emergency exit, it must meet the remaining door design standards.

(5) Direct visual inspection means by crewmembers of the locking mechanism of external doors may provide for visual observation of the door frame and the latching components for engagement or for visual observation of "flag" areas of the locking mechanism. If "flag" areas are used (such as tabs or shoulders which protrude into the crewmember's line of sight when the latches are engaged (locked)), care should be taken to assure that the tab is permanently affixed (or an integral part) to the locking mechanism; and it should not give erroneous readings to the crewmembers under any foreseeable operation or failure of the latching mechanism. "Visual means to signal" to crewmembers "when normally used external doors are closed and fully locked" may be provided by annunciator panel lights or equivalent means. The visual indicating system may consist of an indicator for each individual door, or a system connecting all doors in series. If the latter system is used, it need not necessarily show which door is not fully locked. It is not necessary that more than one crewmember be able to ascertain by a visual signal that all external doors normally used by the crew in supplying the rotorcraft, or in loading and unloading passengers and cargo, are fully closed and locked. The visual signal should be located so that it may easily be seen by the appropriate crewmember from his station.

(6) For § 29.783(f), the auxiliary safety latching device to "prevent the door from opening when the primary latching mechanism fails" can be provided by the same multiple load path features which meet the § 29.783(c) requirement for prevention of door opening in flight after a "mechanical failure." If a completely separate "auxiliary safety latching device" is used, it should allow the door to be opened from the inside, or outside, when in place. If the device must be removed to allow use of the door, "suitable operating procedures" (i.e., placards and RFM instructions) will be required for removal of the device during takeoff and landing.

(7) Additional standards for "airstair doors" were added by Amendment 29-20.

(i) An analysis or test may be used to prove compliance with deformation standards in § 29.783(g)(1).

(ii) A sketch, drawing, or demonstration may be used to prove the door is useable for the conditions described in § 29.783(g)(2).

AC 29.783A. § 29.783 (Amendment 29-31) DOORS.

a. Explanation.

(1) Amendment 29-30 extends the requirements of § 29.783 to:

- include each external door, not just passenger doors; and,

- require provision of door location and/or door operation procedures to protect persons from danger from propellers, engine intakes, and engine exhausts. (Protection from rotors are already included in the standard.)

(2) Amendment 29-31 adds a new paragraph (h) to § 29.783 which requires for doors used for ditching egress to have a means to secure the "ditching exits" in an open position and remain securely open in the appropriate Sea State used for compliance with § 29.801, paragraph AC 29.801.

b. Procedures. The procedures of paragraph AC 29.783 continue to apply to § 29.783 (and Amendment 29-31) with the following additions:

(1) Occupants of the rotorcraft and servicing personnel are now required to be protected from injury when using any external door to enter or egress the rotorcraft and when loading cargo or servicing the rotorcraft. Consideration should be given to door location and/or operating procedures to include protection from propellers (if equipped) and engine inlets and exhausts, as well as from rotors.

(2) These new standards clarify that engine exhausts, engine inlets, and propellers, as well as rotors, are potentially hazardous and should be located or designed to protect rotorcraft occupants and ground personnel or use door latching and operating procedures to protect those persons. Operating procedures for the door, including readily visible markings, should be provided to minimize injury to personnel when practical component locations or component design features, alone, do not assure possible freedom from injury.

(3) For § 29.783(h), a means such as a cable, chain, pin, or mechanical linkage should be provided to secure doors used as ditching exits in the open position. The means should be shown to be effective under rotorcraft attitudes and dynamic conditions common to ditching. The sea states for ditching approval in accordance with § 29.801 are found in paragraph AC 29.801. Demonstrations under actual ditching conditions are not mandated for substantiation purposes, but the substantiation methodology should be reliable, i.e., an analytical or test method demonstrated to be reliable and used in previous structural substantiation programs.

(i) Verify that the Model APU is listed as qualified to TSO-C77(a) or other suitable specifications. Note that TSO qualification is not regulatory but simply defines an acceptable base qualification standard. Other standards may be acceptable or deviations from the TSO may be acceptable if evaluated and found not pertinent to the planned installation.

(ii) Review the installation data provided for the APU and determine that the installation is in compliance. Exceptions may be taken as discussed above. Note that the TSO provides different qualification standards for "essential" and "nonessential" service APU's. However, it does not distinguish between "flight-use" and "ground-use-only" APU's. Some deviations to the TSO may be authorized based on this aspect; i.e., operation during negative "g" conditions.

(iii) Review Part 29, especially subparts E and F for all rules related to engines, engine support/service systems, intakes, exhausts, instrumentation, fire protection, pneumatic systems, etc., for applicability to installation and operation of the APU. Develop and accomplish a compliance program for the rules identified by this review following policy and procedures used for engines with exceptions which may be justified as discussed above.

(iv) For reference, the following rules specifically refer to APU's. Some comments regarding compliance are offered.

(A) Section 29.1041, Cooling. APU installation data should define limits to be substantiated.

(B) Section 29.1091, Air Induction. Note the requirements of paragraph (f).

(C) Section 29.1103, Induction System Ducts. Note the special requirements of paragraphs (a), (e), and (f).

(D) Section 29.1121, Exhaust Systems.

(E) Section 29.1142, Controls.

(F) Section 29.1181, Designated Fire Zones.

(G) Section 29.1191, Firewalls. Firewall construction should be provided to completely separate the APU from other parts of the rotorcraft.

(H) Section 29.1195, Fire Extinguishers. Note that only one adequate discharge is required.

(I) Section 29.1203, Fire Detector Systems. Detectors are required for each fire zone which would include APU installations.

(J) Section 29.1305, Powerplant Instruments. TSO-C77(a) specifies provisions for measuring gas temperature, rotor RPM, and any other parameter necessary for safe operation of the APU.

(K) Section 29.1337, Powerplant Instruments.

(v) Additional comments. APU fuel sources which tap into engine fuel systems should be carefully designed and arranged to minimize the probability that an APU fuel line failure will jeopardize continued normal engine operation. If the APU provides essential services, it should be provided with an independent fuel system. Also, engine fuel systems which operate at negative pressures should not be tapped for APU fuel source since air leaks back through the APU fuel control or small leaks in the APU fuel system likely will fail the engine.

AC 29.901A. § 29.901 (Amendment 29-26) INSTALLATION.

a. Explanation. Amendment 29-26 changes § 29.901(b)(2) to require a satisfactory determination that the rotorcraft can operate safely throughout adverse environmental conditions such as high altitude and temperature extremes. This amendment was needed to provide consistent application of the environmental qualification aspects of the installation. This amendment also added a new paragraph § 29.901(b)(6) to require design precautions to minimize the potential for incorrect assembly of components and equipment essential to safe operation.

b. Procedures. All of the policy material pertaining to this section remains in effect with the addition of design precautions. Design precautions should be taken to minimize the possibility of improper assembly of the components essential to the safe operation of the rotorcraft. Fluid lines, electrical connectors, control linkages, etc., should be designed so that they cannot be incorrectly assembled. This can be achieved by incorporating different sizes, lengths, and types of connectors, wires, fluid lines, and mounting methods. The applicant should perform a detailed maintenance assessment to clearly define the maintenance requirements, reliability, and serviceability of the drive system design. The applicant should consider all design qualification tests and service history data, if available. A review of accident data supports the importance of this assessment. Some applicants have utilized drive system vibration monitoring to verify continuing safe operation of their drive system.

AC 29.901B. § 29.901 (Amendment 29-36) INSTALLATION.

a. Explanation. Prior to Amendment 29-36, paragraph (c) exempted engine rotor disc failures (engine rotorburst) from consideration as a failure that could jeopardize the safe operation of the rotorcraft. Amendment 29-36 removes this exclusion. Therefore, engine rotor disc failures should be considered as a failure that would jeopardize the safe operation of the rotorcraft.

b. Procedures. The method of compliance for this section is unchanged.

testing (including any failures or degradation) should be taken into consideration. Previous service experience with similar designs should also be taken into account (see also § 29.601(a)).

c. Definitions. For the purposes of this assessment, failure conditions may be classified according to the severity of their effects as follows:

(1) Minor. Failure conditions which would not significantly reduce rotorcraft safety, and which involve crew actions that are well within their capabilities. Minor failure conditions may include, for example, a slight reduction in safety margins or functional capabilities, a slight increase in crew workload, such as routine flight plan changes, or some inconvenience to occupants.

(2) Major. Failure conditions which would reduce the capability of the rotorcraft or the ability of the crew to cope with adverse operating conditions to the extent that there would be, for example, a significant reduction in safety margins or functional capabilities, a significant increase in crew workload or in conditions impairing crew efficiency, or discomfort to occupants, possibly including injuries.

(3) Hazardous. Failure conditions which would reduce the capability of the rotorcraft or the ability of the crew to cope with adverse operating conditions to the extent that there would be--

(i) A large reduction in safety margins or functional capabilities;

(ii) Physical distress or higher workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely;

(iii) Serious or fatal injury to a relatively small number of the occupants;

(iv) Loss of ability to continue safe flight to a suitable landing site.

(4) Catastrophic. Failure conditions which would prevent a safe landing.

(5) Minimize. Reduce to the least possible amount by means that can be shown to be both technically feasible and economically justifiable.

(6) Health Monitoring. A Vibration Health Monitoring System (VHM) is used to acquire and process helicopter drive system vibration signals.

(i) The principal purpose of a VHM is to increase the likelihood of detection of incipient faults in the rotor drive system that could prevent continued safe flight and safe landing by providing timely warning of potential failures to the pilot and maintenance personnel.

(ii) VHM data can be used to improve the helicopter's monitoring practices to mitigate a major or a hazardous/severe failure. The VHM data can also be used to improve maintenance.

(iii) A VHM system can be used to monitor all or some critical components of the rotor drive systems. Critical components include the input driveshaft to the main gearbox from the engine, bearings, tail rotor drive shaft, hanger bearings, one way clutch, main rotor mast and tail rotor mast. The supplier should state the component coverage and the fault detection capability for all affected components. The health monitoring effectiveness should be validated by tests or analysis or both.

(iv) Typically, a VHM system consists of sensors (e.g., accelerometers and tachometer), signal acquisition, signal processing, data management, VHM alert generation and management, a pilot interface, and a maintenance interface.

(v) Signal Processing: The helicopter's rotors, its drive systems and engines are a mixture of complex and simple mechanical elements. Therefore, the sensors and signal processing and analysis techniques utilized should reflect the complexity of the mechanical elements and their vibratory modes.

(vi) AC 29 MG-15 provides airworthiness approval guidance for rotorcraft health usage monitoring systems. This guidance can be used for incorporating VHM.

d. Failure Analysis.

(1) The first stage of the design assessment should be the Failure Analysis, by which all the hazardous and catastrophic failure modes are identified. The failure analysis may consist of a structured, inductive bottom-up analysis, which is used to evaluate the effects of failures on the system and on the aircraft for each possible item or component failure. When properly formatted it will aid in identifying latent failures and the possible causes of each failure mode. The failure analysis should take into consideration all reasonably conceivable failure modes in accordance with the following:

(i) Each item/component function(s).

(ii) Item/component failure modes and their causes.

(iii) The most critical operational phase/mode associated with the failure mode.

(iv) The effects of the failure mode on the item/component under analysis, the secondary effects on the rotor drive system and on the rotors, on other systems and on the rotorcraft. Combined effects of failures should be analyzed where a primary failure is likely to result in a secondary failure.

(v) The safety device or health monitoring means by which occurring or incipient failure modes are detected, or their effects mitigated. The analysis should consider the safety system failure.

(vi) The compensating provision(s) made available to circumvent or mitigate the effect of the failure mode (see also paragraph (1) below).

(vii) The failure condition severity classification according to the definitions given in paragraph (c) above.

(2) When deemed necessary for particular system failures of interest, the above analysis may be supplemented by a structured, deductive top-down analysis, which is used to determine which failure modes contribute to the system failure of interest.

(3) Dormant failure modes should be analyzed in conjunction with at least one other failure mode for the specific component or an interfacing component. This latter failure mode should be selected to represent a failure combination with potential worst-case consequences.

(4) When significant doubt exists as to the effects of a failure, these effects may be required to be verified by tests.

e. Evaluation of Hazardous and Catastrophic Failures.

(1) The second stage of the design assessment is to summarize the hazardous and catastrophic failures and appropriately substantiate the compensating provisions that are made available to minimize the likelihood of their occurrence. Those failure conditions that are more severe should have a lower likelihood of occurrence associated with them than those that are less severe. The applicant should obtain early concurrence of the cognizant certificating authority with the compensating provisions for each hazardous or catastrophic failure.

(2) Compensating provisions may be selected from one or more of those listed below, but not necessarily limited to this list.

(i) Design features; i.e., safety factors, part-derating criteria, redundancies, etc.

(ii) A high level of integrity: All parts with catastrophic failure modes and critical characteristics are to be identified as Critical Parts and be subject to a Critical Parts Plan (see AC 29.602.). Where a high level of integrity is used as a compensating provision, parts with a hazardous failure mode which would prevent continued safe flight may be included in a Critical Parts Plan or subjected to other enhancements to the normal control procedures for parts.

(iii) Fatigue tolerance evaluation.

(iv) Flight limitations.

(v) Emergency procedures.

(vi) An inspection or check that would detect the failure mode or evidence of conditions that could cause the failure mode.

(vii) A preventive maintenance action to minimize the likelihood of occurrence of the failure mode, including replacement actions and verification of serviceability of items which may be subject to a dormant failure mode.

(viii) Special assembly procedures or functional tests for the avoidance of assembly errors which could be safety critical.

(ix) Safety devices or use of vibration health monitoring systems are recommended in addition to those provisions identified in paragraphs e.(2)(vi) and e.(2)(vii).

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AC 29.921. § 29.921 ROTOR BRAKE.

a. Background. Rotor brake safety requirements are intended not only to prevent adverse effects on aircraft performance due to brake drag but also to minimize the possibility of fires. These fires, caused by friction from a dragging rotor brake, have occurred both in flight and during ground operation with extremely hazardous consequences.

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[Section AC 29.921 continued on next page.]

b. General. This rule requires (1) that any limitations on the use of the rotor brake must be established, and (2) that the control for the brake must be guarded to prevent inadvertent operation.

c. Limitations.

(1) The limitations on the use of the rotor brake should first be defined by the applicant and will normally consist of merely the maximum rotor speed eligible for application of the brake. In some installations, limitations associated with engine operation may be specified. For example, some “free power section” type turbine engines can be safely operated within certain low limits with the rotor brake engaged, while other engines cannot tolerate this condition. At least one manufacturer has included a maximum rotor speed for emergency rotor brake application. This is considered an enhancing safety consideration and is recommended.

(2) Control guard mechanisms to prevent inadvertent operation may be conventional. A cockpit evaluation should be conducted by flight test personnel to affirm the function of the guard and the brake, and that markings, if any, are adequate and that both latched and unlatched positions of the control do not interfere with other cockpit functions.

d. General qualification aspects should include:

(1) The 400 applications required by § 29.923(j) conducted as a part of the § 29.923 endurance test.

(2) Torsional vibration measurements of the loads in the brake components and the rotor drive system during a critical brake engagement procedure, with appropriate consideration in the fatigue evaluation for these components. Brake engagements should be conducted with and without collective control displacement as authorized by the flight manual or a training manual.

(3) Brake component temperature measurements during a critical brake application in conjunction with an evaluation of the general brake compartment for compliance with §§ 29.863 and 29.1183.

(4) Placards, decals, and flight manual limitations and instructions appropriate to operate the rotor brake safely.

(5) An evaluation for hazardous failure modes as required by § 29.901(c). If the brake hydraulic system is integral with the rotorcraft hydraulic system, failure modes of pressure regulators and control valves, including valve leakage, will be of interest. Mechanical cams, calipers, and levers may be prone to seize or fail to release the brake due, in part, to corrosion and lack of lubrication to be expected when brake components encounter high temperature cycling

fuel quantity indication, and caution/warning parameters, as a minimum, presented by a common display driven by a common processor.

(4) Discussion. This design philosophy does not result in the traditional requirement for individual display independence for failure/malfunction considerations. This loss of independence means that a single failure could result in loss of most, if not all, instrument displays on the integrated display system. Redundancy of the integrated display system is often proposed to compensate for this lack of independence. However, redundancy alone may not meet the integrity requirements since they are derived from the level of criticality associated with the loss or malfunction of instrument/parameter displays for flight operations that are dependent on these indications.

(5) Certification Approach. A two step procedure should be used to determine the adequate safety level for this type of system. The first step is to determine the level of criticality associated with the total loss/malfunction of these functions/indications or loss/malfunction of the critical parts of the display. This can be achieved through the use of a functional hazard assessment (FHA). This criticality assessment must be a product of failure/malfunction of the indication system and the flight operation that would represent the worst case for loss of this information. The second step is to determine that the design integrity of the system is at least equal to the assessed criticality level determined in step one.

(6) Functional Hazard Assessment. The operational classifications to be considered when assessing the criticality are Cat A, Cat B, and IFR. The need for critical information varies with each of these different operational categories. An example would be the demand for OEI parameter information in the single engine Cat A operation. Another example is the loss of fuel quantity indication and fuel low level indication simultaneously in IFR flight conditions. The FHA should address not only loss of one type of indication, but combined loss of engine parameter indication, including total loss of display information, caution/warning, fuel quantity indication, and any other included display in combination with a particular flight operation. There are techniques to lessen the consequences of the failure/malfunction requirements for integrity, such as providing back-up displays for the information deemed critical for a particular operational consideration.

(7) Summary. The loss of all integrated display information for certain types of flight operations may have the highest level of criticality associated with it. The same may be true for malfunctions that result in misleading indications. These failures/malfunctions must be addressed by the commensurate design integrity level. Lesser levels of criticality must also be addressed by the appropriate design integrity levels.

AC 29.1305C. § 29.1305 (Amendment 29-40) POWERPLANT INSTRUMENTS.

a. Explanation. Amendment 29-40 added section 29.1305(a)(6) to require an oil pressure indicator for each pressure-lubricated gearbox. Paragraphs (a)(6) through (a)(25), prior to this amendment, have been redesignated as paragraphs (a)(7) through (a)(26).

b. Procedures. In addition to providing an oil pressure indicator for each pressure-lubricated gearbox, the guidance material of the previous AC 29.1305 paragraphs continues to apply.

AC 29.1307. § 29.1307 (Amendment 29-12) MISCELLANEOUS EQUIPMENT.

a. Explanation. This rule provides a listing of several items of required miscellaneous equipment. Each item is self-explanatory, except for the one requiring a master switch arrangement for electrical circuits other than ignition. The purpose of a master switch arrangement is to allow rapid removal of all bus loads from sources of electrical power in an emergency situation. Requirements for radio communications are discussed more in AC 29.1431.

b. Procedures. When reviewing possible solutions to the master switch arrangement requirement, the following considerations should be included.

(1) System separation. Since wiring from each electrical system will be brought in close proximity to each other, extra care should be taken to maintain some separation. As examples, common connectors, common grounds, and common wire routing should be avoided.

(2) Installation of switches. The single switch should be avoided since it introduces the possibility of a single failure turning off the entire electrical system. One solution that is commonly used provides a close grouping of the switches such that the pilot can easily reach all switches and turn them all off with one action. This solution requires a cockpit evaluation to ensure the installation will be suitable for different hand sizes. Another solution involves a gang bar that can be moved with a single motion to turn off all sources. This solution has been found to be acceptable in several instances. Other solutions should be evaluated on their own merits, and the primary emphasis should be on maintaining some minimum system separation and conducting a cockpit evaluation by flight test personnel.

AC 29.1309. § 29.1309 (Amendment 29-40) EQUIPMENT, SYSTEMS, AND INSTALLATIONS.

a. Explanation.

(1) Applicability. Federal Aviation Regulation (FAR) paragraph 29.1309 is intended as a general requirement that is applicable to any equipment or system as installed, in addition to specific systems requirements, except as indicated below.

(3) Prevent the loss of lubricant in the event of failure of the retention device for the removable portion of the chip detector (debris monitor).

(4) Provide a test system to allow the crew to check, in flight, the function of each detector and wiring. The test circuit should test, at least, as much of the circuitry as reasonably possible. Where detectors are used that have a test feature in the form of an extra pin, all of the circuit, exclusive of the detector may be tested. Some chip detectors have a fuzz burner capability to eliminate nuisance indication of non-relevant conducting materials that result from oil contamination and very small wear particles.

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SUBPART F - EQUIPMENT

ELECTRICAL SYSTEMS AND EQUIPMENT

AC 29.1351. § 29.1351 (Amendment 29-40) ELECTRICAL SYSTEMS AND EQUIPMENT -GENERAL.

a. Explanation. With the advent of more sophisticated rotorcraft and operations under more critical conditions, such as IFR and icing, it is essential that the electrical system be very carefully analyzed and evaluated to assure proper operation under any foreseeable operating condition, and that hazards do not result from any malfunctions or failures.

b. Procedures.

(1) An acceptable method of preparing an electrical load analysis is given in Military Specification MIL-E-7016F, and use of this standard is preferred since it has received widespread acceptance. If other formats have been used and have been considered acceptable, their continued use is acceptable.

(2) Generating systems must be analyzed, inspected, or tested to assure conformance to the following criteria. Analysis should be performed on the electrical power system emphasizing the exclusion of single point failures and possibilities of latent failures. Test methods should be developed that uncover latent faults. Ref MG-2 for electrical system test methods.

(i) Analyses should be performed on the electrical power system with an emphasis on excluding single point and latent failures. Also, evaluate the non-monitored functions by selecting test conditions that use every signal path and decision point between the input and output. Test methods should be developed that uncover latent faults. Refer to MG-2 for electrical system test methods.

(ii) For Category A, the generating system must perform as specified in § 29.1309(d) and (e).

(iii) No probable malfunction in the generating system or in the generator drive system may result in loss of service to electric utilization systems which are necessary to maintain controlled flight and to affect a safe landing, unless the aircraft is equipped with an independent source of electrical power capable of supplying continuous emergency service to these utilization systems. A probable malfunction is any single electrical or mechanical component malfunction or failure that is likely to occur based on past service experience. This past service experience can include malfunction of components of previously approved rotorcraft, other aircraft, or qualitative analysis of similar components in rotorcraft applications. These analyses should be extended to multiple malfunctions when:

(A) The first malfunction would not be detected during normal operation of the system, including periodic checks established at intervals which are consistent with the degree of hazard involved; or

(B) The first malfunction would inevitably lead to other malfunctions.

(3) The generator drive system includes the prime movers (propulsion engines or other) and coupling devices such as gear boxes or constant speed drives.

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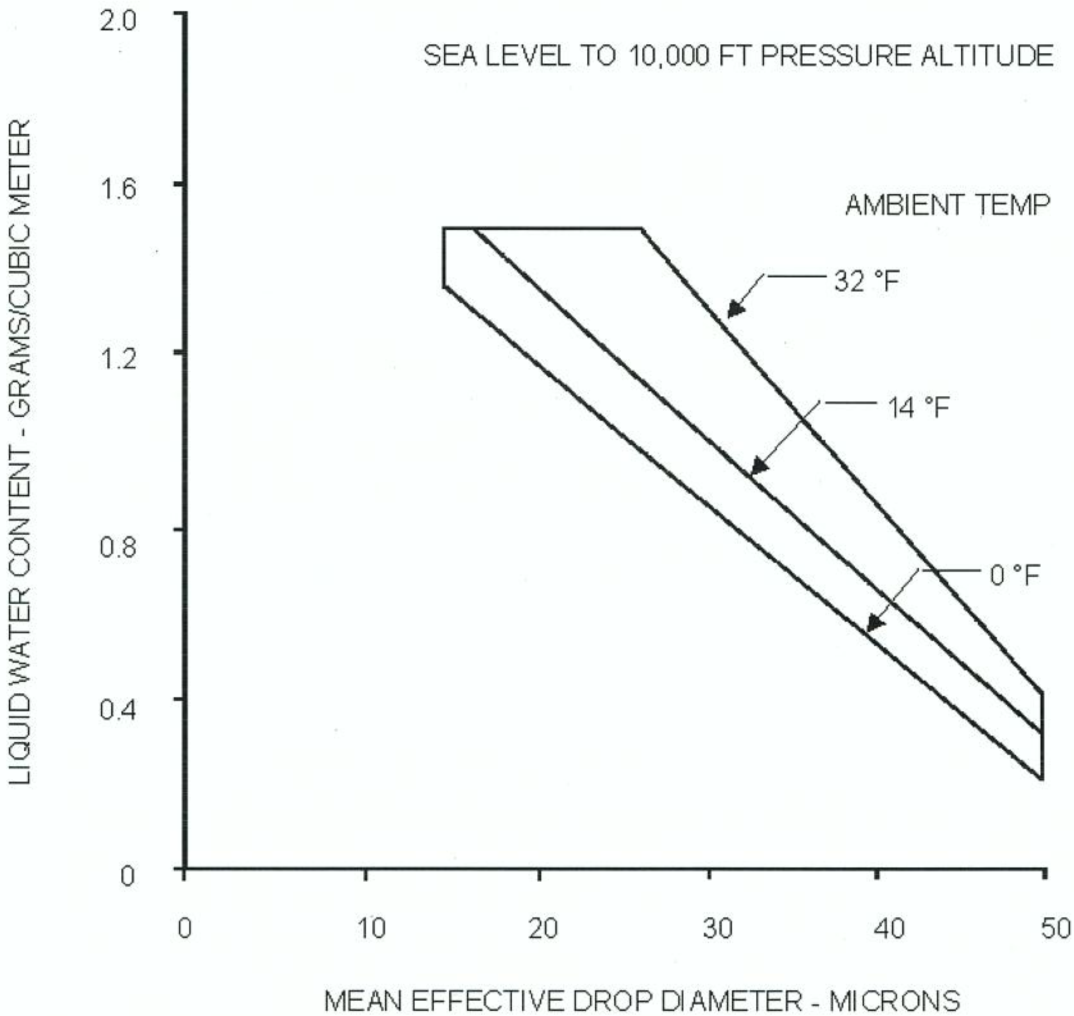

FIGURE AC 29.1419-4 INTERMITTENT ICING - LIQUID WATER CONTENT VS DROP DIAMETER

Figures AC 29.1419-1 through 4 represent one approach to a 10,000-foot altitude limit. See Paragraph b(5)(iii) for a discussion of this approach.

SUBPART F - EQUIPMENT

MISCELLANEOUS EQUIPMENT

AC 29.1431. § 29.1431 ELECTRONIC EQUIPMENT.

a. Background. This section contains some specific requirements for electronic equipment in the rotorcraft. The principal requirements of this section are that radio and navigation equipment must be free from hazards, both in themselves and in their effect on any other items installed in the rotorcraft, and that operation of the radio and navigation equipment does not interfere with operation of any other required avionics. The increased use of complex equipment that integrates communication and navigation functions increases the likelihood of common mode failures resulting in simultaneous loss of communication and navigation functions. Total non-restorable loss of communication and navigation information is considered to be a catastrophic failure condition for IFR operations.

b. Procedures. In showing compliance with this section, tests and analysis should be performed as necessary to determine that:

(1) All radio and navigation equipment is installed and operated in such a manner that it does not result in hazards to the rotorcraft. It also should not have an effect on any other components of the rotorcraft to the extent that it creates a hazardous condition. Consideration should be given to the effects of critical environmental conditions. The environment can easily be the cause of common mode failures. Temperature extremes in the rotorcraft may exceed the temperature to which the system was qualified. Additional considerations include:

(i) An analysis, per SAE ARP 4761, to assure there is no single condition or fault which can cause multiple channels, systems, circuits, etc. to fail simultaneously. An example of this could be a common power supply for both communication and navigation functions.

(ii) Addressing each potential common cause fault case and identifying the corresponding mitigation or assurance for precluding that fault. Examples of this are shown in MG-13.

(iii) Mitigating features which include "shake and bake" testing on each LRU, dissimilar design, and architecture considerations such as simplex back-up systems.

(2) All radio and navigation systems and equipment should be installed and operated in a manner that will not have a detrimental effect on the proper functioning of any electronic equipment or system required by the FAR. It should be noted that §§ 29.1301 (reference paragraph AC 29.1301) and 29.1309(b) through (d) (reference paragraph AC 29.1309) apply to all installed equipment and systems and § 29.1309(a)

applies to all systems and equipment required by Parts 21 through 49. As an example of showing compliance with this section, consider a high frequency radio (HF) system installation. The first thing to determine is that the installation and operation of the HF system cannot create a hazard. Consideration may be necessary in hazardous situations such as precipitation on the antenna. Next, it should be determined that the operation of the HF does not cause interference to a system whose functioning is required by the FAR. An example of unacceptable interference would be if operating the HF transmitter caused one of the navigation radios to malfunction.

(3) Finally, it should be determined that other systems do not interfere with the HF system. Additional guidance on the testing of avionics equipment and installation is contained in paragraph AC 29 MG 1.

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AC 29.1433. § 29.1433 VACUUM SYSTEMS.

a. Explanation. Vacuum systems have been utilized on some rotorcraft to provide an energy source for the flight instruments. This specific rule addresses the potential hazards which are peculiar to vacuum system installations. The possible fire hazards presented by these systems are of particular concern.

b. Procedure. The following items should be specifically addressed when evaluating a vacuum system installation:

(1) Pressure and Temperature Protection. The high-pressure outlet of the vacuum pump should have a means to automatically relieve the pressure if it becomes excessively high or the air temperature becomes excessively hot.

(2) Fire Hazard Protection. The components of the vacuum system that are mounted in a designated fire zone should be fire resistant. This includes engine or transmission driven pumps if they are in a fire zone. The discharge side of the pump may emit flammable fluids. This discharge side of the pump, along with its associated lines and fittings, should meet the criteria in paragraph AC 29.1183.

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AC 29.1435. § 29.1435 HYDRAULIC SYSTEMS.

a. Reference Regulations. The following sections of Part 29 are either incorporated in the provisions of § 29.1435 or are otherwise applicable to hydraulic system design:

(1) Section 29.695. Paragraph AC 29.695 covers power boost and power operated control systems.

(2) Section 29.861. Paragraph AC 29.861 covers fire protection of structure, controls, and other parts.

(3) Section 29.863. Paragraph AC 29.863 covers flammable fluid fire protection.

(4) Section 29.1183. Paragraph AC 29.1183 covers lines, fittings, and components.

(5) Section 29.1185. Paragraph AC 29.1185 covers flammable fluids.

(6) Section 29.1189. Paragraph AC 29.1189 covers shutoff means.

(7) Section 29.1309. Paragraph AC 29.1309 covers the requirements for functioning and reliability, and prevention of hazards if malfunctions or failures occur.

(8) Section 29.1322. Paragraph AC 29.1322 covers warning, caution, and advisory lights.

b. System Design. It is assumed that the hydraulic system is to be utilized to operate the primary control system of the rotorcraft and the rotorcraft cannot be safely operated without the hydraulic system.

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[Section AC 29.1435 continued on next page.]

(1) Section 29.1309, paragraphs (a) and (b), provides for functioning reliably under any foreseeable operating condition and prevention of hazards after any malfunction or failure.

(2) The substantiating data should include a failure analysis that considers every possible system component failure, such as (but not limited to) ruptured lines, pump failure, regulator failure, ruptured seals, clogged filters, broken pilot valve connections, etc.

(3) The requirements of § 29.1309(a) and (b) are met by dual independent hydraulic systems from the reservoir, hydraulic pump, regulator, connecting tubing, and hoses through the actuators. There must be no commonality in the fluid-containing components. A break in one system should not result in fluid loss in the remaining system.

(4) The pumps should be separated as far as practicable; i.e., on opposite sides of the rotor drive transmission, on separate engines, or one pump on an engine and the other on the rotor drive transmission. The tubing and hoses should also be routed with as much physical separation as practicable. The purpose of this separation is to prevent total loss of the hydraulic systems in the event of a malfunction such as fire, or rotor burst wherein one projectile could disable both systems.

(5) Dual actuators must be designed to assure that any single failure, such as a cracked housing, broken interconnecting input, or output link, does not result in loss of total hydraulic system function.

(6) If the assumption under (b) above does not apply and the pilot can control the rotorcraft without undue fatigue after loss of the hydraulic system, then a single hydraulic system is acceptable.

(7) The pressure-indicating system required by § 29.1435, paragraph (a)(3), can be satisfied with a dial, vertical scale, or digital indicator. The indicator should enable the crew to detect pressure trends. Paragraph AC 29.1322 concerns § 29.1322 regarding proper colors for annunciators if they are used to supplement the indicating system.

(8) An analysis or a combination of analysis and tests must be included in the substantiating data file to show compliance with paragraphs (a)(1), (a)(2), and (a)(4) of § 29.1435.

(9) Extra caution should be exercised to assure that control input forces at the mechanical connection to the actuator pilot valves do not exceed their intended value. Consideration should be given to the most adverse tolerance buildup in parts fabrication and control system rigging.