U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: CERTIFICATION OF TRANSPORT CATEGORY ROTORCRAFT

Date: 11/19/84
Initiated by: ASW-110

AC No: 29-2
Change: 1

1. PURPOSE. This change revises existing material in three paragraphs and adds material for 60 paragraphs previously shown as "RESERVED."

   The change number and date of changed material are carried at the top of each page. The asterisks (*) in the right and left margins indicate the beginning and end of each change. Rearranged pages having no new material also carry the change number and new date. Pages having no changes retain the same heading information. In paragraphs that are entirely new, asterisks appear only in the margins at the beginning and the end of each new page.

2. PRINCIPAL CHANGES.

   a. Paragraphs 81, 336, and 762 are revised.

   b. New paragraphs 4, 8, 12, 16, and 24 are added as Chapter 1 material.

   c. New paragraphs 121, 122, 123, 140, 152, 153, 159, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 205, 206, 207, 251, 252, 267, 268, 332, 334, 335, 338, 339, 340, 341, 342, 343, 344, 485, 487, 498, 499, 501, 502, 503, 504, 505, 516, 517, 518, 640, 743, 763, 764, 765, and 766 are added to Chapter 2.

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CHAPTER 1. PART 21

CERTIFICATION PROCEDURES FOR PRODUCTS AND PARTS (Amendment 21-50)

* 1.-3. RESERVED.

4. § 21.16 SPECIAL CONDITIONS.

a. The Process. Chapter 2, Section 1, paragraph 8 of the Type Certificate Handbook, Order 8110.4, provides detailed guidance on the special conditions process. However, much of that material has been outdated with the implementation of the Aircraft Certification Directorate Program. Rotorcraft special conditions are processed through the Helicopter Policy and Procedures Staff, ASW-110. That office will assure coordination with the affected agency and industry elements including the Regional Counsel. All comments will be considered and the disposition documented by the Rotorcraft Directorate. ASW-1 will issue the special conditions.

b. Basis for Development.

(1) Special conditions are justified on the basis of the existing Part 29 being inadequate or inappropriate due to novel or unusual design features of the rotorcraft to be certificated.

(2) The phrase "novel or unusual" as used in § 21.16 is a very relative term. As used hereafter in applying § 21.16 to justify the issuance of special conditions, "novel or unusual" will be taken with respect to the state of technology envisaged by the applicable airworthiness standards of this subchapter. It must be recognized that in some areas which will vary from time to time, the state of the regulations may somewhat lag the state of the art in new design because of the rapidity in which the state of the art is advancing in civil aeronautical design and because of the time required to develop the experience base needed by the FAA to proceed with general rulemaking. Applicants for type certification of a new design have the opportunity to mitigate the impact of not knowing the precise airworthiness standards to be applied for "novel or unusual design features" by consulting with the FAA early in their certification planning when such features are suspected or known by the applicant to exist. It should also be recognized that, because of the intentional objective nature of the airworthiness standards of this subchapter, many new design features which might be thought of as "novel or unusual" may already be adequately covered by existing regulations, thus obviating the need to issue special conditions.

(3) Before proposing special conditions, the certification staff should very thoroughly analyze the existing regulations and assure they are inadequate or inappropriate in light of a new and novel design feature.

* 5.-7. RESERVED.

8. § 21.31 TYPE DESIGN.

The regulatory basis for requiring data to define the design is contained in § 21.31. This section is self-explanatory and broad enough in scope to give the certification staff access to sufficient data to determine compliance with Part 29.

9.-11. RESERVED.

12. § 21.33 INSPECTION AND TESTS.

a. Applicant Responsibility. Section 21.33 requires the applicant to:

(1) Assure the test rotorcraft conforms to the type design. This must be accomplished prior to presentation to the FAA for testing.

(2) Conduct all inspections and tests necessary to determine compliance with the airworthiness and noise requirements.

b. FAA Responsibility.

(1) The design evaluation engineers should assure that the type design is adequate in their technical area and that the inspections and tests to be conducted are appropriate and sufficient to show compliance with Part 29.

(2) As changes to the rotorcraft are made during the test program, the flight test crew should assure that the appropriate design evaluation engineer concurs with the change and the conformity inspection of the change has been conducted. *

13.-15. RESERVED.

* 16. § 21.35 FLIGHT TESTS.

a. Explanation.

(1) This section outlines the requirements of the applicant for aircraft type certification and should be used in conjunction with Order 8110.4, Section 5. Section 21.35 requires, in part, that the applicant conduct sufficient flight tests to show compliance with the flight requirements throughout the proposed flight envelope. The results of the applicant's flight test should be submitted to the FAA in report form for evaluation to determine what verification flight tests the FAA may elect to conduct. The report should conclude that in the applicant's opinion the test aircraft complies with the applicable certification requirements. The FAA verification flight test should include, but not be limited to, the critical or marginal results contained in the applicant's flight test report. The FAA's role in the certification effort is not envisioned to be one of conducting day-to-day routine flight tests with the applicant, but only to verify his results through limited sampling. In certain tests, such as high altitude testing at a remote mountain site, there is an advantage in conducting flight tests concurrently with the applicant. Additionally, the FAA can provide technical flight test assistance to the applicant in certain cases. This can be done after a cursory review and a letter of authorization is issued to the flight test crew.

(2) Preflight Test Planning. After the applicant's flight test report is reviewed, it should be determined what FAA engineering flight tests are necessary. These tests are normally specified in the Type Inspection Authorization (TIA). At the same time the FAA must know and agree to the applicant's proposed means of data aquisition, reduction, and expansion of the flight test data. The adequacy of the test instrumentation should be evaluated prior to official type certification tests (reference paragraph 24).

(3) Order of Testing. The Federal Aviation Regulations are so worded that the results of some flight tests have a definite bearing on the conduct of other tests. For this reason, and to minimize retesting, careful attention should be given to the order of testing. The exact order of testing will be determined only by considering the particular rotorcraft and test program involved. Tests which are particularly important in the early stages of the program are:

(i) Airspeed calibration: All tests involving airspeed depend upon the calibration.

(ii) Engine power available determination.

(iii) Engine cooling.

(4) Test Groupings.

(i) Weight and c.g.: In addition to the regulatory relationship of one test to another, efficient testing requires that consideration be given to the accomplishment of as many tests on a single flight as can be accommodated successfully.

* (ii) Special instrumentation. Similarly, consideration should be given to grouping of tests that involve special instrumentation. Examples of these are takeoff and landing tests which usually require group equipment to record horizontal distance, height, and time. Ground calibration of the airspeed indicating system can be accomplished at the same time. It is the applicant's responsibility to provide the necessary instrumentation.

b. Procedures.

(1) Type Certification Flight Tests.

(i) Prior to initiating official FAA flight tests, a conformity inspection of the test aircraft must be accomplished. This is needed to assure that the test aircraft is in the proper configuration or "conforms" to the engineering drawings and documents that have been submitted to FAA, evaluated, and approved. It is absolutely essential to know the configuration being tested in any engineering flight evaluation. Conformity inspection prior to TIA flight tests assures that testing will not be wasted because of configuration uncertainties.

(ii) Certification Handbook 8110.4, paragraph 67, contains a requirement that the applicant must keep the FAA advised of any configuration changes to the aircraft. The manufacturing inspector should keep the FAA flight test pilot apprised of any change which may affect safety of the test aircraft or may influence test results.

(iii) Results of the conformity inspection and the engineering flight test program must be documented. This is normally done in the Type Inspection Report (TIR). Results may be documented in any acceptable engineering format. The report should be in sufficient detail to clearly show how compliance with each appropriate section of the rules was determined.

(iv) The flight test pilot must assure that the FAA manufacturing inspector and certification engineer are aware of all configuration changes found necessary as a result of FAA tests. The manufacturing inspector is responsible for assuring that all changes are incorporated into production drawings after the design data reflecting the change have been approved by the certification engineer.

(v) Additional flight test responsibilities, procedures, and requirements during the certification flight test process are contained in Certification Handbook 8110.4, Section 5, Flight.

(2) Function and Reliability Tests.

(i) A comprehensive and systematic check of all aircraft components must be made to assure that they perform their intended function and are reliable.

(ii) Function and reliability (F&R) testing must be accomplished on an aircraft which is in conformity with the approved production configuration. F&R testing should follow the type certification testing described in paragraph (1) above to assure that significant changes resulting from type certification tests can be incorporated on the aircraft prior to F&R tests. •

ILLUSTRATIONS

The first block of digits in the figure number denotes the associated paragraph number. The second block of digits denotes the figure number within the paragraph. The figure is located at the end of the paragraph.

* (iii) All components of the rotorcraft should be periodically operated in sequences and combinations likely to occur in service. Ground inspections should be made at appropriate intervals to identify potential failure conditions; however, no special maintenance beyond that described in the aircraft maintenance manual should be allowed.

(iv) A complete record of defects and failures should be maintained along with required servicing of aircraft fluid levels. Results of this record should be consistent with inspection and servicing information provided in the aircraft maintenance manual.

(v) A certain portion of the F&R test program may emphasize systems, operating conditions, or environments found particularly marginal during type certification tests.

(vi) See Handbook 8110.4, paragraph 166(c), for additional information and procedures.

17.-23. RESERVED.

24. § 21.39 FLIGHT TEST INSTRUMENT CALIBRATION AND CORRECTION REPORT.

a. Explanation. It is the applicant's responsibility to provide instrumentation for all parameters needed to show compliance with the airworthiness regulations.

(1) For those data which are necessary to show compliance with the regulations, a permanent record should be established. A permanent record is acceptable in either graphical or photographic form, and in some instance a manual recording may be satisfactory.

(2) Regardless of the record form, the accuracy of the record must be established by reference to a laboratory standard traceable to the National Bureau of Standards.

(3) If multiplexing is used, the time base must be synchronized to a reference point from which the magnitude of each parameter can unquestionably be determined. Also, the sampling rate should be sufficiently frequent to assure that the maxima, minima, and trends of magnitude of the parameter are recorded with respect to time.

b. Procedure. Prior to conducting flight tests, the FAA flight test team should review the applicant's flight test instrumentation calibration and correction report. *

* (1) Normally the frequency of instrument calibration should not exceed 90 days. However, the frequency of recalibration varies with the consistency of the instrumentation under consideration. For example, cyclic and collective position is sometimes calibrated immediately before and after a flight where these parameters are used to provide critical flight data. Six months is a typical interval for recording/signal conditioning and nonstrain gage sensors, while one year is typical for strain gaged components. Also, environmental effects such as vibration, humidity, temperature, etc., should be considered when determining whether recalibration is necessary.

(2) The highest and lowest magnitude of the parameter being recorded should be considered when establishing the scale for instrumentation. Ideally, the highest magnitude throughout the flight would fall on the maximum indicating point of the recording. *

25.-30. RESERVED.

SECTION 4. FLIGHT CHARACTERISTICS

80. § 29.141 (through Amendment 29-19) FLIGHT CHARACTERISTICS - GENERAL.

a. Explanation.

(1) This regulation prescribes the general flight characteristics required for certification of a transport category helicopter. Specifically, it states that the helicopter shall comply with the flight characteristics requirements at all approved operating altitudes, gross weights, center of gravity locations, airspeeds, power, and rotor speed conditions for which certification is requested. While § 29.141(a) does not specifically refer to ambient temperature, the reference to "altitude" in § 29.141(a)(1) is correctly interpreted as "density altitude." Density altitude is, of course, a function of pressure altitude and ambient temperature, hence the need to account for ambient temperature effects. Additional flight characteristics required for instrument flight are contained in paragraph 775 of this advisory circular.

(2) Generally the aircraft structural (load level) survey accounts for takeoff power values at speeds up to and including V_y. At speeds above V_y, maximum continuous power is assumed. Stress to rotating components usually increases with airspeed and power. If the takeoff power rating exceeds the maximum continuous power rating, and the structural survey has been conducted under the assumption that takeoff power is not used at speeds above V_y, the Rotorcraft Flight Manual must limit takeoff power to speeds of V_y and below. If takeoff power is structurally substantiated throughout the flight envelope, and appropriate portions of the controllability, maneuverability, and trim requirements of §§ 29.141 through 29.161 are met at takeoff power levels, no flight manual entry is needed. Obviously if transmission limits for MC and takeoff power are coincident, no special action is needed.

(3) During the flight characteristics testing, the controls must be rigged in accordance with the approved rigging instructions and tolerances. The control system rigging must be known prior to testing. In addition to the normal rigging procedures, any programmed control surfaces which may be operated by dynamic pressure, electronics, etc., must also be calibrated. During the flight test program, it is frequently necessary to rig a control, such as the swashplate or tail rotor blade angle, to the allowable critical extreme of the tolerance band. For example, it would be necessary to rig the tail rotor to the minimum allowable blade angle if meeting the requirements of § 29.143(c) would be in question. The same consideration must be given to all helicopter controls and moveable aerodynamic surfaces where questionable compliance with the regulations may exist. If the rotor-induced vibration characteristics of the helicopter are significantly affected and require time-consuming rigging for such things as acceptable ride comfort, then the rotor(s) should be rigged to the allowable extreme tolerance limits to determine compliance, for example, with § 29.251.

(4) During the FAA flight test program, the crew should be especially alert for conditions requiring great attentiveness, high skill levels, or exceptional strength. If any of these features appear marginal, it is advisable to obtain another pilot's opinion and to carefully document the results of these evaluations. Section 29.141(b) provides the regulatory basis for these strength and skill requirements. The general requirements for a smooth transition capability between appropriate flight conditions are also included in § 29.141(b). These requirements must also be met during appropriate engine failure conditions for each category of rotorcraft.

(5) For night or IFR approval, § 29.141(c) contains the general regulatory reference which requires additional characteristics for night and IFR flight. The appropriate flight test procedures are included in other portions of this order.

81. § 29.143 (through Amendment 29-19) CONTROLLABILITY AND MANEUVERABILITY.

a. Explanation.

(1) This regulation contains the basic controllability requirements for transport rotorcraft. It also specifies a minimum maneuvering capability for required conditions of flight. The general requirements for control and for maneuverability are summarized in § 29.143(a) which is largely self-explanatory. The hover condition is not specifically addressed in § 29.143(a)(2) so that the general requirement may remain applicable to all rotorcraft types, including those without hover capability. For helicopters, the hover condition clearly applies under "any maneuver appropriate to the type."

* (2) Paragraphs (b) through (e), § 29.143, include more specific flight conditions and highlight the typical areas of concern during a flight test program. *

(i) Section 29.143(b) specifies flight at V_{NE} with critical weight, center of gravity (c.g.), rotor rpm, and power. Adequate cyclic authority must remain at V_{NE} for nose down pitching of the rotorcraft and for adequate roll control. Nose down pitching capability is needed for control of gust response and to allow necessary flight path changes in a nose down direction. Roll control is needed for gust response and for normal maneuvering of the aircraft. In the past, 10 percent control margin has been applied as an appropriate minimum control standard. The required amount of control power, however, has very little to do with any fixed percentage of remaining control travel. There are foreseeable designs for which 5 percent remaining is adequate and others for which 20 percent may not be enough. The key is, can the remaining longitudinal control travel at V_{NE} generate a clearly positive nose down pitching moment, and will the remaining lateral travel allow at least 30-degree banked turns at reasonable roll rates? Moderate lateral control reversals should be included in this evaluation and since available roll control can diminish with sideslip, reasonable out of trim conditions (directionally) should be investigated. This "control remaining" philosophy must also be applied for other flight conditions specified in this section.

(ii) Section 29.143(c) requires a minimum 17-knot control capability for hover and takeoff in winds from any azimuth. Control capability in wind from 0 to at least 17 knots must also be shown for any other appropriate maneuver near the ground such as rolling takeoffs for wheeled rotorcraft. These requirements must be met at all altitudes approved for takeoff and landing. On helicopters incorporating a tail rotor, efficiency of the tail rotor decreases with altitude so that a given sideward flight condition requires more pedal deflection, a higher tail rotor blade angle, and more horsepower. Hence, directional capability in sideward flight (or at critical wind azimuth) is most critical during testing at a high altitude site. Hover controllability, height-velocity, and hover performance are the three regulatory requirements that ordinarily determine the shape of the limiting weight-altitude-temperature (WAT) curve for takeoff and landing at high density altitudes. For Category A rotorcraft, of course, one engine inoperative climb performance requirements may also influence the WAT limit curve.

(iii) Section 29.143(d) requires adequate controllability when an engine fails. This requirement specifies conditions under which engine failure testing must be conducted and includes minimum required delay times. *

(A) For rotorcraft which meet the engine isolation requirements of Category A, demonstration of sudden complete single-engine failure is required at critical conditions throughout the flight envelope including hover, takeoff, climb at V_y, and high speed flight up to V_{NE}. Entry conditions for the first engine failure are engine or transmission limiting maximum continuous power (or takeoff power where appropriate) including reasonable engine torque splits. For multiengined Category A installations (3 or more engines) subsequent engine failures should be conducted utilizing the same criteria as that used for first engine failure. The applicant may limit his flight envelope for subsequent failures. Initial or sequential engine failure tests are ordinarily much less severe than the "last" engine failure test required by § 29.75(b)(5). The conditions for last engine failure are maximum continuous power, or 30-minute power if that rating is approved, level flight, and sudden engine failure with the same pilot delay of 1 second or normal pilot reaction time, whichever is greater.

(B) For Category B, demonstration of sudden complete power failure is required at critical conditions throughout the flight envelope. This includes speeds from zero to V_{NE} (power-on) and conditions of hover, takeoff, climb at V_y, and high speed flight up to V_{NE}. Maximum continuous power is specified prior to the failure, and for cruise conditions, no pilot reaction may begin prior to 1 second or normal pilot reaction time (whichever is greater). Normal pilot control motions which are part of the pilot task of flight path control are not subject to the 1-second restriction on pilot reaction. The term "cruise" also includes cruise climb and cruise descent conditions. Normal pilot reaction times are used elsewhere. Although this requirement specifies maximum continuous (MC) power, it does not limit engine failure testing to MC power. If a takeoff power rating is authorized for hover or takeoff, engine failure testing must also be accomplished for those conditions in order to comply with § 29.63(c). Following power failure, rotor speed, flapping, and aircraft dynamic characteristics must stay within structurally approved limits. *

* (iv) Section 29.143(e) addresses the special case in which a V_{NE} (power-off) is established at an airspeed value less than V_{NE} (power-on). For this case, engine failure tests are still required at speeds up to and including V_{NE} (power-on) and the rotorcraft must be capable of being slowed to V_{NE} (power-off) in a controlled manner with normal pilot reactions and skill. There is, however, no controllability requirement for stabilized power-off flight at speeds above 1.1 V_{NE} (power-off) when V_{NE} (power-off) is established per § 29.1505(c).

Application of the controllability requirement for pitch, roll, and yaw at speeds of 1.1 V_{NE} (power-off) and below is similar to that described above for power-on testing at V_{NE}. Sufficient directional control must exist to allow straight flight in autorotation during all approved maneuvers including 30 degrees banked turns up to V_{NE} (power-off) with some small additional allowance for gust control. Adequate controllability margins must exist in all axes throughout the approved autorotative flight envelope. Testing to V_{NE} at MC power per § 29.143(b), 1.1 V_{NE} at power for .9 V_H per § 29.175(b) or § 29.1505, and to 1.1 V_{NE} (power-off) in autorotation per § 29.143(e) should be sufficient to assure adequate control margin during a descent condition at high speed and low power. The high speed, power-on descent condition should be checked for adequate control margin as a "maneuver appropriate to the type." There has been one instance where insufficient directional pedal was available to maintain a reasonable trimmed sideslip angle with low power at very high speeds, and a case where there was insufficient forward and lateral cyclic available to reach the power on V_{NE}. The insufficient directional pedal margin was due to the offset vertical stabilizers. The lack of cyclic stick margin was because the cyclic stick migrated to the right as power was reduced, and the control limits were circular. This provided less total available forward cyclic stick travel when the cyclic was moved right and forward about 45° from the center position. Each of the above helicopters was certificated with a rate of descent limitation to preclude operation in the control limited area.

An evaluation of the emergency descent capability of the helicopter should be made, either analytically or through flight test. Areas of consideration are the rate of descent available, the maximum approved altitude, and the time before a catastrophic failure following the loss of transmission oil pressure, a fuselage fire, or other similar failure. Each helicopter should have the capability to descend to sea level and land from the maximum certificated altitude within the time period established as safe following a critical failure.

b. Procedures.

(1) Flight test instrumentation should include ambient parameters, all flight control positions, rotor rpm, main and tail rotor flapping (if appropriate), engine power instruments, and throttle position. Flight controls that are projected to be near their limits of authority should be rigged to the most adverse production tolerance. A very accurate weight and balance computation is needed along with a precise knowledge of the aircraft's weight/c.g. variation as fuel is burned.

(2) The critical condition for V_{NE} controllability testing is ordinarily aft c.g., MC power, and minimum power-on rotor rpm, although power and rpm variations should be specifically evaluated to verify their effects. The turbine engine is sensitive to ambient temperatures which affect the engine's ability to produce rated maximum continuous torque. Flight tests conducted at ambient temperatures that cause the turbine temperature to limit maximum continuous power would not produce the same results obtained at the same density altitude at colder ambient temperatures where maximum continuous torque would be limiting. Forward c.g. should be spot checked for any "tuck under" tendency at high speed. The V_{NE} controllability test is normally accomplished shortly after the 1.1 V_{NE} (or 1.1 V_h) point obtained during stability tests required by § 29.175(b). Controllability must be satisfactory for both conditions. If V_{NE} varies with altitude or temperature, V_{NE} for existing ambient conditions is utilized for the test. Extremes of the altitude/temperature envelope should be analyzed and investigated by flight test.

(3) The critical condition for controllability testing in a hover is ordinarily forward c.g. at maximum weight with minimum power-on rotor rpm. For rearward flight testing of configurations where the forward c.g. limit varies with weight, low or high gross weight may be critical. Lateral c.g. limits should also be investigated. A calibrated pace vehicle is needed to assure stabilized flight conditions. Surface winds should be less than 3 knots throughout the test sequence. Testing can be done in higher stabilized wind conditions (gusting less than 3 knots); however, these conditions are very difficult to find and the method is very time consuming due to the necessity of waiting for stabilized winds. Testing in calm winds is preferred. Hover controllability testing should be accomplished with the lowest portion of the helicopter at the published hover height above ground level; however, the test altitude above the ground may be increased to provide reasonable ground clearance. Although the necessary yaw response will vary somewhat from model to model, sufficient control power should be available to permit a clearly recognizable yaw response after full directional control displacement when the helicopter is held in the most critical position relative to wind.

(4) Prior to engine failure testing, it is mandatory that the pilot be fully aware of his engine, drive system, and rotor limits. These limits were established during previous ground and flight tests and they should be specified in the TIA. Particular attention should be given to minimum stablized and minimum transient rotor rpm limits. These values must be included in the TIA and should be approached gradually with a build-up in time delay unless the company testing has completely validated all pertinent aspects of engine failure testing. On Category A installations the maximum power output of each engine must be limited so that when an engine fails and the remaining engine(s) assume the additional load, the remaining engine(s) are not damaged by excessive power extraction and over-temping. This is needed for compliance with § 29.903(b). The propulsion engineer should have assured that this feature was properly addressed in the engine and drive system substantiation; however, it must be assumed that for some period of time the pilot may extract maximum available power from the remaining engine(s) when an engine fails during critical flight maneuvers. Substantiation of this feature should be accomplished primarily by engine and drive system ground tests.

* (5) Longitudinal cyclic authority at V_{NE} with any power setting must permit suitable nose down pitching of the rotorcraft. If the remaining control travel is considered marginal, tests should include applications up to full control deflection to assess the remaining authority. Some knowledge of the aircraft's response to turbulence is useful in assessing the remaining margin. As a minimum, the rotorcraft must have adequate margin available to overcome a moderate turbulent gust and must not have any divergent characteristic which requires full deflection of the primary recovery control to arrest aircraft motion. If other controls must be utilized to overcome adverse aircraft motion, the results are unacceptable; e.g., if a pitch up tendency resulting from an actual or simulated moderate turbulent gust cannot be satisfactorily overcome by remaining forward cyclic, the use of throttle or collective controls to assist the recovery is not an acceptable procedure; however, the use of lateral cyclic to correct roll in conjuction with forward cyclic to correct pitchup is satisfactory. Obviously during the conduct of these tests, all available techniques should be utilized when the pilot finds himself "out of control." However, compliance with this section requires that recovery must be shown by use of only the primary control for each axis of aircraft motion. *

(6) Cyclic control authority in autorotation must be sufficient to allow adequate flare capability and landing under the all engine inoperative requirements of § 29.75(b)(5) and (c). See paragraph 67 of this advisory circular.

82. <u>§ 29.161 (through Amendment 29-19) TRIM CONTROL</u>.

a. <u>Explanation</u>.

(1) The pilot has many tasks to perform with each hand during sustained flight conditions. The trim requirement is intended to provide the pilot with a reference cyclic control position for the given flight condition, reduce the physical demands to maintain a given flight condition, and allow the pilot to release the cyclic control for brief periods of time to perform other cockpit duties. A primary flight control which can move when released imposes an additional pilot workload by requiring a continuous hands-on condition. It is not intended to require that control forces be reduced to zero by the trim control during dynamic maneuvers such as takeoff acceleration.

(2) A number of devices may be used to produce the necessary trim characteristics. One popular method of meeting this requirement is through the use of control balance springs in conjunction with a small amount of built-in control system friction. Other methods include use of friction, magnetic brakes, bungees, and irreversible mechanical schemes.

(3) This regulation is not intended to require zero friction or zero breakout force in the control system, nor is it intended to require automatic control recentering. The regulation, in fact, specifically prohibits excessive high friction or high breakout forces which would produce undesirable discontinuities in the primary control force gradient.

* 140. § 29.351 (through Amendment 29-19) YAWING CONDITIONS.

a. Explanation. The rule requires proof of a rotorcraft "structural" yaw or sideslip design envelope. This sideslip envelope must cover minimum forward speed or hover to V_H or V_{NE}, whichever is less. The helicopter must be structurally safe for the thrust capability of the directional control system.

(1) The rotorcraft structure must be designed to withstand the loads for the specified yaw conditions. The standard does not require a structural flight demonstration. It is a structural design standard.

(2) Maximum displacement of the directional control, except as limited by pilot effort (130 pounds; § 29.397(a)), is required for the conditions cited in the rule. A control system rate limiter or a yaw damper may be used. The total displacement is therefore a function of time as well as the maximum effort applied (130 pounds).

(i) At low airspeeds, 90° yaw (sideward flight) should be the design limit.

(ii) At high airspeeds, stabilized yaw angle (stabilized sideslip) must be substantiated as stated in the rule.

(iii) At high airspeeds, the maximum tail rotor thrust will be combined with the vertical (directional) stabilizer surface load, if a stabilizer is used, as specified by § 29.351(b)(1).

(iv) At high airspeeds, while the rotorcraft is in the sideslip condition, the directional control is then returned to the neutral position, attendent with the flight condition. The tail rotor thrust will be added to the restoring force of the vertical stablizer.

(v) Both right and left yaw conditions should be proven.

(3) The tail rotor attachment structure must comply with § 29.403.

(4) The vertical stabilizing surface must also comply with § 29.413.

b. Procedures.

(1) Many of the current single main rotor rotorcraft designs have vertical (directional) stabilizing surfaces. These surfaces may be solely vertical stabilizing fins as on the Bell Model 206, or a swept vertical extension of the tail boom as on the Hiller Model FH1100. The Hiller FH1100 tail surface houses the tail rotor drive shaft and the tail rotor output gearbox.

(i) For vertical stabilizers, the airloads may be assumed independent of the tail rotor thrust. *

* (ii) For vertical stablizers that house the tail rotor output gearbox, such as the *Hiller Model FH1100*, the *tail surface air loads will add to* or subtract from the tail rotor thrust according to the flight condition under consideration.

NOTE: For one example: At stablized yaw to the right (left pedal depressed to limit) (§ 29.351(b)(2)), the tail rotor thrust moment should equal the restoring moment of the tail boom, vertical stabilizer and main rotor torque. As stated by § 29.351(b)(3), the tail rotor thrust moment then is added to the vertical stabilizer restoring moment. The addition of tail rotor thrust (§ 29.351(b)(3)) and vertical stabilizer load is generally one of the critical design conditions for the fuselage/tail boom.

(iii) For vertical stablizers or fins that have an offset incidence angle with respect to the helicopter axis, the vertical fin moment is added, or subtracted as applicable, to the tail rotor thrust moment. The condition stated in § 29.351(b)(1) may result in adding the fin load to the tail rotor thrust.

(iv) Low airspeed maneuvers, such as sideward, rearward, and hover turns over a spot, typically impose insignificant aerodynamic loads on the fuselage and/or tail boom. The aerodynamic loads at V_H or V_{NE}, whichever is required, are generally the significant aerodynamic design loads.

(v) A rational assessment of the various yaw conditions may be used to reduce the load deviation and analysis to the critical rotorcraft design conditions.

(vi) The helicopter structure shall be analyzed or tested for loads derived from the critical design conditions.

(vii) A simple structural design envelope may be derived from these design data. If the right or left yaw limits are not very different, common, conservative design limits may be used. A sample yaw/forward speed diagram, as *derived from design analysis of the characteristics of a hypothetical helicopter,* is presented in Figure 140-1. A table of values would also suffice. This figure reflects characteristics which include a 90° yaw when the directional control inputs are applied at low airspeeds (up to 30 knots presumably the maximum sideward flight speed of which this aircraft is capable) and 10° yaw when they are applied at V_H, with a straight line variation from 30 knot forward speed to V_H. •

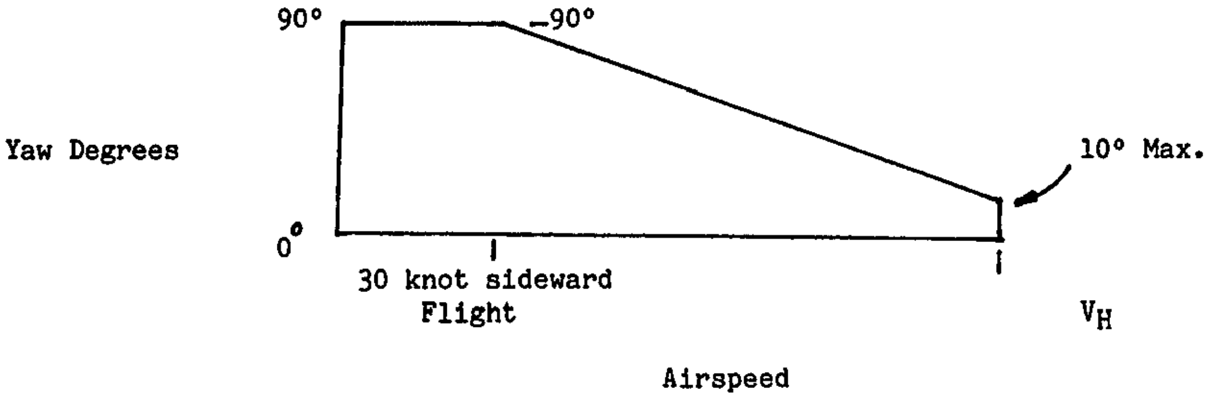

FIGURE 140-1

* (viii) During flight test evaluations, yaw angles have been measured using a yaw angle probe (swiveling vane type) on a nose boom. Both a visual readout for the pilot and a record, such as an oscillograph trace, have been used. This test may be conducted in the flight test program or in the flight load survey program. This record should confirm the yaw angle used in design as conservative with respect to operational and actual flight characteristics. This test is not a requirement however.

141. § 29.361 (through Amendment 29-19) ENGINE TORQUE.

a. Explanation.

(1) The rotorcraft should be designed for limit engine torque values, as prescribed by the rule, to account for maximum engine torque, including transients and torsional oscillations. The rule recognized that reciprocating (piston) engines generate higher torque oscillations than turbine engines.

(2) A factor of 1.25 applies to maximum continuous power for turbine engines.

(3) Torque factors are also specified for reciprocating engines having two or more cylinders § 29.361a.2. The appropriate torque factor applies to takeoff power torque as well as maximum continuous power and other power conditions.

(4) Paragraph 206 of this document concerns § 29.549(e) that contains standards associated with 2 1/2-minute power rating.

b. Procedures.

(1) The engine torque associated with the maximum continuous power condition must be multiplied by the appropriate torque factor to obtain the engine torque value used for structural substantiation purposes of the rotorcraft.

(2) The torque values associated with the minimum power-on rpm limit should be used. Maximum power-on speed limit will result in a lower torque value when calculating torque from design horsepower values. However, due to piston engine power output characteristics, an engine may produce a higher torque at higher engine speeds contrary to the previous statement. The torque factor should account for this characteristic.

142.-151. RESERVED.

SECTION 7. STRENGTH REQUIREMENTS - GENERAL

* 121. § 29.301 (through Amendment 29-19) LOADS.

a. Explanation.

(1) The rule is a general statement concerning limit and ultimate loads, and the application of these loads to the rotorcraft.

(2) Ultimate loads are limit loads multiplied by the prescribed factors of safety.

(3) The specified loads must be distributed appropriately or conservatively and signficant changes in distribution of the loads, as a result of deflection, must be taken into account.

b. Procedures. The design criteria report and/or design loads report must contain data that comply with the rule.

122. § 29.303 (through Amendment 29-19) FACTOR OF SAFETY.

a. Explanation.

(1) Unless otherwise provided by FAR Part 29, a factor of safety of 1.5 is required and is applied as stated in the rule. This safety margin will assure that the design strength of the rotorcraft is greater than the design loads contained in FAR Part 29.

(2) Other rules, §§ 29.561(b)(3) and 29.787(c), specify use of defined ultimate inertia forces for protection of occupants.

b. Procedures.

(1) The design criteria report and/or design loads report must contain data that include the appropriate factor of safety.

(2) The factor of safety multiplies the limit external and inertia loads. The rule does allow the application of this factor to the resulting "limit internal" stresses if it is more conservative.

123. § 29.305 (through Amendment 29-19) STRENGTH AND DEFORMATION.

a. Explanation.

(1) This general rule defines, in relative terms, allowable deformation for limit and ultimate loads.

(2) The structure must support, in a static test, ultimate loads for 3 seconds without failure or dynamic tests simulating actual load application may be used. *

* (3) Section 29.307 concerns proof of the structure and requires certain specified tests. This rule also allows substantiation by structural analysis. See paragraph 124 of this advisory circular.

b. Procedures. Any test results, static or dynamic, must satisfy the limitations or acceptance criteria contained in the rule.

(i) Any test proposals submitted for approval that are used to demonstrate compliance with sections of FAR Part 29 must contain the criteria stated in the rule.

(ii) Any test results reports shall contain data and information showing the test results comply with the standard.

124. § 29.307 (through Amendment 29-19) PROOF OF STRUCTURE.

a. Explanation.

(1) The rule requires compliance for each critical loading condition. Certain tests must be conducted as specified. Additional tests for new or unusual design features may be required as noted in subparagraph (b)(6).

(2) "Structural analysis may be used only if the structure conforms to those for which experience has shown this method to be reliable."

(3) Fatigue substantiation requirements are explained further in paragraph 230, § 29.571 of this advisory circular.

b. Procedures.

(1) The design criteria and/or design loads report should contain typical or representative loading conditions from which the critical loading conditions will be selected for analytical substantiation in structural (static and fatigue) reports and dynamics (vibration and stability) reports and fatigue, static, dynamic, or operational test reports.

(2) Whenever tests are used or required, a test proposal or plan must be approved prior to the tests. The test article must have received conformity inspections and must have been accepted by the FAA for the test. Test fixtures and instrumentation must also be acceptable to the FAA (using DER's as appropriate) prior to start of the test. The quality control office of the applicant or other qualified pesonnel may be authorized to conduct inspections of the test fixtures and instrumentation rather than the FAA or DER performing this task. The test proposal may be used to define and to authorize the means to accomplish inspection of the test fixtures and instrumentation. Unnecessary drawings, such as test fixture details, or layering of approvals is not intended or envisaged by this policy. Drawings, sketches or photographs have been used by the FAA to control and to assure correct location, direction, and magnitude of loads and other critical test parameters.

(3) Structural analysis has been accepted for rotorcraft in place of static tests. Generally the helicopter airframe should have frequency placements remote to predominate rotor excitation sources, including rotor harmonics, to avoid undesirable and possibly excessive vibration and potentially high operating stress levels due to this vibration. During the flight load measurement program conducted under § 29.571, critical loaded areas or critical joints may be instrumented with strain gages or other stress strain measuring devices. This actual flight data may be compared to the analytical data to verify accuracy.

(4) Subparagraph (b) of the rule specifies certain tests. Test proposals must be approved prior to conducting official FAA tests. Other paragraphs in this advisory circular pertain to those tests.

125. § 29.309 (through Amendment 29-19) DESIGN LIMITATIONS.

a. Explanation.

(1) The rule requires an orderly selection and presentation of the basic structural design limitations of the rotorcraft. The applicant must establish these structural limitations to facilitate design of the rotorcraft.

(2) Refer to the rule for the specific requirements.

b. Procedures.

(1) The design criteria and/or design load report should contain the design limits specified.

(2) These items are structural design limits. Other requirements may result in narrowing the ranges of type design limits or in reducing limits. It is not necessary to revise structural design criteria limits to agree with more conservative operational limits established during the certification program. The operational limits may be subsequently expanded by additional flight tests to agree with design limits.

126.-135. RESERVED.

Chapter 10. HYDRAULIC AND PNEUMATIC SYSTEMS

Section 1. HYDRAULIC SYSTEMS

392. GENERAL. Maintain, service, and adjust airplane hydraulic systems in accordance with manufacturers' maintenance manuals and pertinent component maintenance manuals. Certain general principles of maintenance and repair which apply are outlined below.

393. HYDRAULIC LINES AND FITTINGS. Carefully inspect all lines and fittings at regular intervals to insure airworthiness. Investigate any evidence of fluid loss or leaks. Check metal lines for leaks, loose anchorages, scratches, kinks, or other damage. Inspect fittings and connections for leakage, looseness, cracks, burrs, or other damage. Replace or repair defective elements.

a. Replacement of Metal Lines. When inspection shows a line to be damaged or defective, replace the entire line or if the damaged section is localized, a repair section may be inserted. In replacing lines, always use tubing of the same size and material as the original line. Use the old tubing as a template in bending the new line, unless it is too greatly damaged, in which case a template can be made from soft iron wire. Soft aluminum tubing (1100, 3003, or 5052) under ¼-inch outside diameter may be bent by hand. For all other tubing use an acceptable hand or power tube bending tool. Bend tubing carefully to avoid excessive flattening, kinking, or wrinkling. Minimum bend radii values are shown in figure 10.1. A small amount of flattening in bends is acceptable but do not exceed an amount such that the small diameter of the flattened portion is less than 75 percent of the original outside diameter. When installing the replacement tubing, line it up correctly with the mating part so that it is not forced into line by means of the coupling nuts.

b. Tube Connections. Many tubing connections are made using flared tube ends, and standard connection fittings: AN-818 nut and AN-819 sleeve.

Tube O.D. (inches)	Wrench torque range for tightening tube nuts (inch pounds)		Minimum bend radii measured at inside of bend. Dimension in inches. *	
	Alum. alloy 1100-H14, 5052-O	Steel	Alum. alloy 1100-H14, 5052-O	Steel
⅛		30-70	⅜	
3/16	40-65	50-90	7/16	21/32
¼	60-80	70-120	9/16	⅞
5/16	75-125	90-150	¾	1⅛
⅜	150-250	155-250	15/16	1 5/16
½	200-350	300-400	1¼	1¾
⅝	300-500	430-575	1½	2 3/16
¾	500-700	550-750	1¾	2⅝
1	600-900		3	3½
1¼	600-900		3¾	4⅜
1½			5	5¼
1¾			7	6⅛
2			8	7

FIGURE 10.1.—Tube data.

In forming flares, cut the tube ends square, file smooth, remove all burrs and sharp edges, and thoroughly clean. The tubing is then flared using the correct 37° aviation flare forming tool for the size of tubing and type of fitting. A double flare is used on soft aluminum tubing ⅜-inch outside diameter and under, and a single flare on all other tubing. In making the connections, use hydraulic fluid as a lubricant and then tighten. Overtightening will damage the tube or fitting, which may cause a failure; undertightening may cause leakage which could result in a system failure.

CAUTION

Mistaken use of 45° automotive flare forming tools will result in improper tubing flare shape and angle causing misfit, stress and strain, and probable system failure.

c. ***Repair of Metal Tube Lines.*** Minor dents and scratches in tubing may be repaired. Scratches or nicks no deeper than 10 percent of the wall thickness in aluminum alloy tubing, that are not in the heel of a bend, may be repaired by burnishing with hand tools. Replace lines with severe die marks, seams, or splits in the tube. Any crack or deformity in a flare is also unacceptable and cause for rejection. A dent less than 20 percent of the tube diameter is not objectionable unless it is in the heel of a bend. Dents may be removed by drawing a bullet of proper size through the tube by means of a length of cable. A severely damaged line should be replaced; however, it may be repaired by cutting out the damaged section and inserting a tube section of the same size and material. Flare both ends of the undamaged and replacement tube sections and make the connection by using standard unions, sleeves, and tube nuts. If the damaged portion is short enough, omit the insert tube and repair by using one union and two sets of connection fittings.

d. ***Replacement of Flexible Lines.*** When replacement of a flexible line is necessary, use the same type, size, and length of hose as the line to be replaced. If the replacement of a hose with swaged-end-type fittings is necessary, obtain a new hose assembly of the correct size and composition. Certain synthetic oils require a specially compounded synthetic rubber hose which is compatible. Refer to the aircraft manufacturer's service information for correct part number for replacement hose. If the fittings on each end are of the collet type or sleeve type, a replacement may be fabricated as shown in figure 10.2. Typical aircraft hose specifications and their uses are shown in figure 10.3. Install hose assemblies without twisting. (See figure 10.4.) Never stretch a hose tight between two fittings as this will result in overstressing and eventual failure. The length of hose should be sufficient to provide about 5 percent to 8 percent slack. Avoid tight bends in flex lines as they may result in failure. Never exceed the minimum bend radii as indicated in figure 10.5.

Teflon hose is used in many aircraft systems because of its superior qualities for certain applications. Teflon is compounded from tetrafluoroethylene resin which is unaffected by fluids normally used in aircraft. It has an operating range of −65° F. to 450° F. For these reasons, Teflon is used in hydraulic and engine lubricating systems where temperatures and pressures preclude the use of rubber hose. Although Teflon hose has excellent performance qualities, it also has peculiar characteristics that require extra care in handling. It tends to assume a permanent set when exposed to high pressure or temperature. Do not attempt to straighten a hose that has been in service. Any excessive bending or twisting will cause kinking or weakening of the tubing wall. Replace any hose that shows signs of leakage, abrasion, or kinking. Any hose suspected of kinking may be checked with a steel ball of proper size. Figure 10.6 shows hose and ball sizes. The ball will not pass through if the hose is distorted beyond limits.

If the hose fittings are of the reusable type, a replacement hose may be fabricated as described in figure 10.2. When a hose assembly is removed the ends should be tied as shown in figure 10.7, so that its preformed shape will be maintained. Refer to figure 10.8 for minimum bend radii of Teflon hose.

All flexible hose installations should be supported at least every 24 inches. Closer supports are preferred. They should be carefully routed and securely clamped to avoid abrasion, kinking, or excessive flexing. Excessive flexing may cause weakening of the hose or loosening at the fittings.

e. **O-Ring Seals.** A thorough understanding of O-ring seal applications is necessary to determine when replacement must be made. The simplest application is where the O-ring merely serves as a gasket when it is compressed within a recessed area by applying pressure with a packing nut or screw cap. Leakage is not normally acceptable in this type of installation. In other installations the O-ring seals depend primarily upon their resiliency to accomplish their sealing action. When moving parts are involved, minor seepage may be normal and acceptable. A moist surface found on moving parts of hydraulic units is an indication the seal is being properly lubricated. In pneumatic systems, seal lubrication is provided by the installation of a grease-impreg-

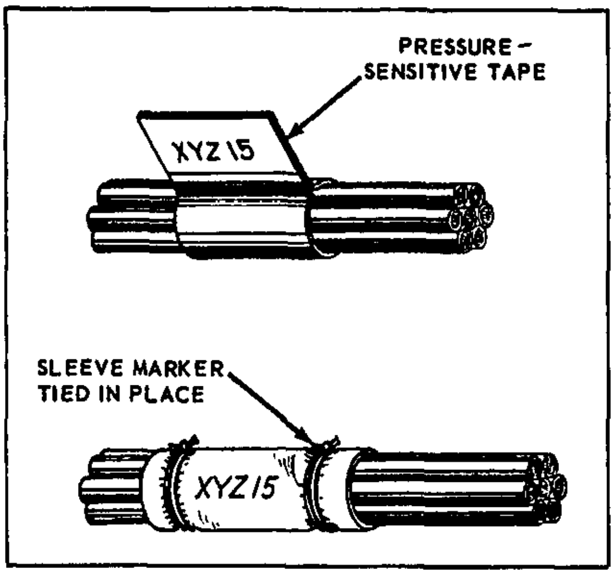

FIGURE 11.19.—Identification of wire bundles and harnesses.

467.–477. RESERVED.

Section 5. CONNECTORS

478. GENERAL PURPOSE CONNECTORS. Connectors (plugs and receptacles) are used to facilitate maintenance when frequent disconnection is required. Since the wires are soldered to the connector inserts, the joints should be individually installed and the wire bundle firmly supported to avoid damage by vibration. Connectors have been particularly vulnerable to corrosion in the past, due to condensation within the shell. Special connectors with waterproof features have been developed and may be used to replace nonwaterproof type plugs in areas where moisture causes a connector problem. Use a replacement connector of the same basic type and design as the connector it replaces. Connectors that are susceptible to corrosion difficulties may be treated with a chemically inert waterproof jelly. When replacing connector assemblies, use the socket-type insert on that half which is live or "hot" after the connector is disconnected to prevent unintentional grounding.

479. TYPES OF CONNECTORS. Connectors are identified by AN numbers and are divided into types and classes with manufacturer's variations in each type and class. The manufacturer's variations are differences in appearance and in the method of meeting the specification; however, they do not preclude mating plugs and receptacles of different manufacturers. There are six basic types of AN connectors used in aircraft which are further broken down into five classes as indicated in figures 11.20 and 11.21. Each class of connector has slightly different construction characteristics which are noted as follows: Classes A, B, C, and D are made of aluminum; Class K is made of steel.

Class A—Solid one-piece back shell general purpose connector.

Class B—Connector back shell separates into two parts lengthwise. Use primarily where it is important that the soldered connectors are readily accessible. The back shell is held together by a threaded ring or by screws.

Class C—A pressurized connector with inserts that are not removable. Looks like a Class A connector but the inside sealing arrangement is sometimes different and is used on walls of bulkheads of pressurized equipment.

Class D—Moisture and vibration resisting connector which has a sealing grommet in the back shell. Wires are threaded through tight fitting holes in the grommet, thereby sealing against moisture.

Class K—A fireproof connector used in areas where it is vital that the electric current is not interrupted, even though connector may be exposed to continuous open flame. Wires are crimped to the pin or socket contacts and the shells are made of steel. This class of connectors is normally longer than the other classes of connectors.

* NOTE: Inspect connectors for loose soldered connections, proper insulation of metallic parts, and fraying of wires in the plug and receptacle inserts. *

480. ARMY/NAVY (AN) CONNECTOR IDENTIFICATION. Code letters and numbers are marked on the coupling ring or shell to identify the connector. This code provides all the information necessary to obtain the correct replacement for a defective or damaged part. To facilitate ready identification the code found on a typical connector (as shown in figure 11.22) is explained as follows:

a. ***The letters AN*** indicate the connector was made to a government standard.

b. ***Type 3106*** indicates this is a straight plug.

c. ***Letter A*** indicates this is a general purpose connector with a solid back shell.

d. ***Number 18*** indicates the size of the coupling. This size is determined in 1/16-inch increments. Therefore, the size of the plug in the example is 1 1/8 inch.

Section 3. MISCELLANEOUS EQUIPMENT

360. PARACHUTES. With reasonable care, parachutes normally last at least 5 years. They should not be carelessly tossed about, left in airplanes so that they may become wet, or left in open places where they may be tampered with. They should not be placed where they may fall on oily floors or be subject to acid fumes from adjacent battery chargers. When repacking is scheduled, a careful inspection of the parachute should be made by a qualified parachute technician (rigger). If repairs or replacements of parts are necessary to maintain the airworthiness of the parachute assembly, such work must be done by the original parachute manufacturer or by a qualified parachute rigger, certificated in accordance with FAR Part 65, or by an appropriately rated parachute loft certificated in accordance with FAR Part 149.

* **361. SAFETY BELTS.** The FARs require that when safety belts are to be replaced in aircraft manufactured after July 1, 1951, such belts must conform to standards established by the FAA.* These standards are contained in Technical Standard Order TSO-C22. Safety belts eligible for installation in aircraft may be identified by the marking TSO-C22 on the belt or by a military designation number since military belts comply with the *strength requirements of the TSO. Each safety belt must be equipped with an approved metal to metal latching device. Airworthy type-certificated safety* belts currently in aircraft may be removed for cleaning and reinstalled. However, when a type-certificated safety belt is found unairworthy, replacement with a TSO-C22 or a new belt is preferred.

* **a.** ***The webbing of safety belts,*** even when mildew-proofed, is subject to deterioration due to constant use, cleaning, and the effects of aging. Fraying of belts is an indication of wear, and such belt are likely to be unairworthy because they can no longer hold the minimum required tensile load.* Difference of opinion as to the airworthiness of a belt can be settled by testing a questionable belt to demonstrate that it will support the required load. Airworthy one-person type-certificated belts should be able to withstand a tensile load of 525 pounds, and TSO belts withstand the rated tensile load indicated on the belt label. Most one-person TSO belts are rated for 1,500 pounds. For two-person belts, double the loads. Since type-certificated belts will not afford the crash protection provided by a TSO or military belt, such type-certificated belts are not to be repaired nor should their buckles or end fittings be reused on safety belts. If replacement of webbing or hardware of TSO or military belt is attempted, use parts of identical design and material. Make the stitch pattern identical to the original and the number of stitches per inch equal to the number used in the original belt. There is no objection to having a greater total length of stitching, provided one line of stitches is not placed over another line. Space lines of stitching at least 3/16-inch apart. Keep a record, preferably in the logbook, stating the extent to which the belt was repaired and the date. Retain the original identification marking on the belt, conforming either to that required by TSO-C22 to a deviation from this marking, or to the military designation. Operators of a fleet of airplanes should follow the above suggestions, but keeping a record of renovations in a logbook is impractical, since the belts are never associated with any one particular aircraft for any length of time. Therefore, in addition to retaining the original identification label and attaching it to the renovated belt, use some additional simple marking to indicate

that the belt has been renovated and show the date of renovation. The use of letter "R" followed by the date would be acceptable. This marking could be in the form of an indelible ink stamping or cloth label stitched to the webbing.

362. FLARES. Parachute flares are made of materials which are subject to decomposition upon aging. Humidity affects the small igniting charge and also the materials of the candle (illuminant). Hence, the percentage of misfires in old flares is likely to be quite high. To assure unfailing performance of flares, periodically inspect the flare installation. Inspect the entire system, starting at the release mechanism in the cockpit and ending at the flare. Only a qualified person should attempt such inspection, since inadvertent discharge of such pyrotechnics may cause serious damage. Past experience has indicated that it is advisable to return all electrically or pistol-operated flares to the manufacturer for reconditioning within a maximum period of 3 years, and that for mechanically operated flares, a maximum period of 4 years is recommended.

363. OXYGEN SYSTEMS.

a. *General.* The following instructions are to serve as a guide for the inspection and maintenance of aircraft oxygen systems. The information is applicable to both portable and permanently installed equipment.

(1) Aircraft Gaseous Oxygen Systems. The oxygen in gaseous systems is supplied from one or more high- or low-pressure oxygen cylinders. Since the oxygen is compressed within the cylinder, the amount of pressure indicated on the system gauge bears a direct relationship to the amount of oxygen contained in the cylinder. The pressure-indicating line connection is normally located between the cylinder and a pressure-reducing valve.

NOTE: Some of the gaseous oxygen systems do not use pressure-reducing valves. The high pressure is reduced to a useable pressure by a regulator. This regulator is located between the high- and low-pressure system.

(2) Aircraft Liquid Oxygen Systems. Thus far it has not been a practice to use liquid oxygen in civil aircraft due to its complexity. This however, may change at any time as technological advances are made.

(3) Portable Oxygen Systems. The three basic types of portable oxygen systems are: demand, pressure demand, and continuous flow. The component parts of these systems are identical to those of a permanent installation with the exception that some parts are miniaturized as necessary. This is done in order that they may be contained in a case or strapped around a person's shoulder. It is for this portability reason that it is essential special attention be given to assuring that any storage or security provision for portable oxygen equipment in the aircraft is adequate, in good condition, and accessible to the user.

NOTE: Check portable equipment including its security provisions frequently, as it is more susceptible to personnel abuse than a permanently installed system.

b. *Inspection.* Hands, clothing, and tools must be free of oil, grease, and dirt when working with oxygen equipment. Traces of these organic materials near compressed oxygen may result in spontaneous combustion, explosions, and/or fire.

(1) Oxygen Tanks and Cylinders. Inspect the entire exterior surface of the cylinder for indication of abuse, dents, bulges, and strap chafing.

(a) Examine the neck of cylinder for cracks, distortion, or damaged threads.

(b) Check the cylinder to determine if the markings are legible.

(c) Check date of last hydrostatic test. If the periodic retest date is past, do not return the cylinder to service until the test has been accomplished.

NOTE: This test period is established by the Department of Transportation in the Code of Federal Regulations, Title 49, Chapter I, Paragraph 173.34.

(d) Inspect the cylinder mounting bracket, bracket hold-down bolts and cylinder holding straps for cracks and deformation, cleanliness, and security of attachment.

(e) In the immediate area where the cylinder is stored or secured, check for evi-

SECTION 9. CONTROL SURFACE AND SYSTEM LOADS

152. § 29.391 (through Amendment 29-19) GENERAL.

a. Explanation. This general rule concerns requirements for design loads of tail rotors, control or stabilizing surfaces, and their control system.

b. Procedures. The design criteria and/or the design loads report must contain the loads dictated by the referenced rules. See paragraphs 153, 154, 155, 156, 157, 158, and 159 of this document.

153. § 29.395 (through Amendment 29-19) CONTROL SYSTEM.

a. Explanation. Control system design loads and the application of these loads are contained in this rule.

(1) Paragraph (a) of the rule specifies the way or means of reacting the design loads specified in §§ 29.397 and 29.399 (for dual control systems). The design loads must be imposed on any locks and stops and irreversible mechanisms in the control system. Both rotor blade horns and control surface horns must react, without failure, the specified loads while the controls are in critical positions.

(2) Paragraph (b) of the rule specifies application of limit pilot forces or of the maximum loads that can be obtained in normal operation, including any single power boost system failure, whichever is greater. However, minimum limit pilot force 0.60 of the loads specified in §§ 29.397 and 29.399, may be used, as specified, in parts of the primary control system that are not stiff enough to react to the loads specified in the first part of paragraph (b) of the rule. Note the objective for a rugged control system.

(3) Control system design feature and test requirements are found in §§ 29.671 through 29.695. Bearing factors and fitting factors are specified in §§ 29.623 and 29.625, respectively.

b. Procedures.

(1) The design criteria and/or a design loads report that includes the primary control system design loads should be submitted for FAA approval.

(2) The rotorcraft control system may be tested to ultimate design loads or may be analyzed for the ultimate design loads. See paragraph 124 of this document.

(i) It is advisable that the applicant prepare a proposal describing the procedures and techniques to be used in the static testing of the control system which reflects compliance with the condition specified. It is further advisable that the FAA concur that the tests proposed achieve that objective. Omission of these steps may result in the need for retesting. The test results should be documented.

* (ii) If tests are not conducted, a structural analysis of the control system is required. Appropriate factors from §§ 29.685(e), 29.623, and 29.625 must be used as specified. A structural analysis report should be used to document compliance with § 29.685(d)(1) and (4), and § 29.685(f).

(3) If a part of the control system is not stiff or rigid enough to react the design loads specified in § 29.397, that part of the system may be substantiated for lower loads as prescribed.

(i) The limit design loads are those loads specified in § 29.397;

(ii) The limit design loads are the maximum that can be obtained in normal operation, including any single power boost system failure, except for objectives stated for a rugged system; and

(iii) In lieu of a rational analysis, the limit design loads may be 0.60 of the loads specified in § 29.397.

(iv) For example, if a control surface servo tab or a small elevator is a part of the helicopter design, the control system for this part must be stiff enough to react the control surface loads without failure and to provide enough surface deflection to control the helicopter. These limit loads may be 60 pounds fore and aft and 40 pounds laterally on the cyclic control stick in lieu of a rational analysis and may be the maximum loads that can be obtained in normal operation.

(v) If a hydraulic power actuation or boost system is part of the helicopter design, the design limit load for the affected parts of the control system will be the maximum output force of the boost at normal operating pressure added to the limit design loads resulting from the loads specified in § 29.397. If a single failure in the power portion of the hydraulic system results in actuator forces that exceed the maximum output force at normal operating pressure, the highest output loads must be used as noted in subparagraph (3)(ii). This hydraulic system failure standard is specified in § 29.695(a)(1) as well.

(4) Controls proof and operation test is required by §§ 29.307(b), 29.681, and 29.683. This test is conducted using the design limit loads approved under § 29.395(b). See paragraphs 282 and 283 of this document. *

154. <u>§ 29.397 (through Amendment 29-19) LIMIT PILOT FORCES AND TORQUES</u>.

a. <u>Explanation</u>. Design forces are contained in the rule.

(1) Primary controls, pilot and copilot, must be designed for the limit pilot forces specified in paragraph (a) of the rule.

(2) For other operating controls, such as flap, tab, stabilizer, rotor brake, and landing gear, design limit forces are specified in paragraph (b).

b. Procedures.

(1) Design loads specified in the rule must be used in required structural tests and in any structural strength analysis of the control systems submitted in compliance with other rules.

(2) Operation tests of the control systems noted in other rules require application of these forces also.

155. § 29.399 (through Amendment 29-19) DUAL CONTROL SYSTEM.

a. Explanation. Design limit loads are specified for dual control systems. Pilot effort forces applied in opposition and in the same direction are required for dual control systems.

b. Procedures.

(1) Design loads specified in the rule must be used in required structural tests and in any structural strength analysis submitted for compliance with the other rules.

(2) Operation tests of the control systems, noted in other rules require application of these forces also.

156. § 29.401 (through Amendment 29-19) AUXILIARY ROTOR ASSEMBLIES.

a. Explanation.

(1) For rotorcraft equipped with auxiliary rotors, normally called tail rotors, an endurance test is required by § 29.923 and structural strength substantiation is required. Section 29.401(b) specifically refers to structural strength substantiation for centrifugal loads resulting from maximum design rotor rpm. Due to the pitch feathering requirements, auxiliary rotors typically have detachable blades.

(2) The rotor blade structure must have sufficient strength to withstand not only aerodynamic loads generated on the blade surface, but also inertial loads arising from centrifugal, coriolis, gyroscopic, and vibratory effects produced by this blade movement. Sufficient stiffness and rigidity must be designed into the blades to prevent excessive deformation and to assure that the blades will maintain the desired aerodynamic characteristics. As a design objective the structural strength requirements should be met with the minimum material. Excess blade weight imposes extra centrifugal loads that may increase the operating stress levels. Blade weight and strength should be optimized. Even though a structural strength analysis for the blade design loads is required, a flight load survey and fatigue analysis are also required by § 29.571.

(3) Section 29.1509 defines the design rotor speed as that providing a 5 percent margin beyond the rotor operating speed limits.

b. Procedure.

(1) The endurance tests prescribed by §§ 29.923 and 29.927 require achieving certain speeds, power, and control displacement for the auxiliary (tail) rotor as well as the main rotor. The parts must be serviceable at the conclusion of the tests.

(2) Structural substantiation of the auxiliary (tail) rotor is required to assure integrity for the minimum and maximum design rotor speeds and the maximum design rotor thrust in the positive and negative direction. Thrust capability of the rotor should offset the main rotor torque at maximum power as required by § 29.927(b).

(i) The maximum and minimum operating rotor speed, power-off, is 95 percent of the maximum design speed and is 105 percent of the minimum design speed, respectively.

(ii) The rotor operating speed limits shown during the official FAA flight tests must include the noted 5 percent margin with respect to the design speeds.

(iii) The auxiliary rotor generally has a positive and negative pitch limit that assures adequate directional control throughout the operating range of the rotorcraft. The power-off rotor speed limits are generally broader than the power-on rotor speed limits because of the required autorotational rotor speed characteristics. Thus, the auxiliary rotor design conditions concern the maximum and minimum design rotor speeds in conjunction with the maximum positive or negative pitch thrust as appropriate. Thrust capability and precone angle of the rotor, if any, will significantly influence the rotor design loads. The variations in rotor design features and an example of substantiation would be too lengthy to include here. However, ANC-9, "Aircraft Propeller Handbook," contains principles that may be applied to tail rotor designs. Tail rotors may be considered a special propeller design.

(iv) Bearings are generally used in the tail rotor installation to allow flapping and feathering motion of the blades. The bearing manufacturer's ratings of these bearings must not be exceeded. Bearings generally used in main and tail rotors are classified as ABEC Class 3, 5, or 7. Class 7 is the highest quality presently available. Satisfactory completion of the endurance tests of §§ 29.923 and 29.927 is a means of proving that use of a particular bearing is satisfactory.

(v) The analysis must include appropriate special factors, casting factors, bearing factors, and fitting factors prescribed by §§ 29.619, 29.621, 29.623, and 29.625, respectively. The fitting factor of 1.15 must be applied in the analysis of the tail rotor installation.

b. Procedures.

(1) The reliability of the means for preventing ground resonance may be substantiated as stated in the standard. An analysis report or a test proposal and subsequent test report may be used to show compliance. The probable range of variations, in service, of the damping action are an important part of the assessment. The test may be conducted in conjunction with the testing required by § 29.241. See paragraph 99.

(i) Analysis and tests may be used.

(ii) Reliable service history of identical or closely similar systems may be used. The materials and fluids used, clearance or fits, seals, and physical installation are important items to be evaluated and considered for "closely similar" systems.

(iii) Testing of the complete rotorcraft may be used to prove that malfunction of a single means of the damping system will not cause ground resonance. One method of demonstrating acceptable compliance is by removing all seals, if practicable, from one damper. Another method is to remove all or most of the fluid, in conjunction with considering the allowable ranges of damping of the other parts of the rotorcraft damping system and operating the rotorcraft throughout the rotor speed range from start to maximum rotor speed. Investigation of elastomeric dampers may require innovative test procedures and preliminary discussions of these prior to preparation of a test proposal. The rotorcraft cyclic control should be displaced as noted in paragraph 99 of this document to assure that the possible rotorcraft resonance frequencies are excited. If vibrations are damped in all tests, the damping system is satisfactory. Each critical rotor damper and landing gear damper, which includes shock struts and tires, should simulate a malfunction to comply with the standard. The testing discussed, however, could become very extensive if one were to attempt to test all combinations of all maintenance adjustments of all components which contribute to the prevention of ground resonance, while at the same time rendering each of the pertinent components ineffective in turn and then repeating all of the maintenance tolerance testing each time. Fortunately, rational analytical methods are available which will permit the evaluation of such combinations so that only the combinations with the least amount of margin used are physically tested.

(2) The pylon damper variation can affect ground resonance. The variations in stiffness and/or damping of pylon mounts should be evaluated except the pylon mounts on contemporary conventional helicopters may have little influence on "classical" ground resonance stability. The dynamics of the rotorcraft on its landing gear is generally established by the airframe properties and the landing gear properties under the influence of the rotor system, with the "pylon" having little effect. For air or flight resonance, the rotor generally couples with the rigid body modes of the fuselage. For a specific design, a relatively simple analysis may be used to show the effect of the pylon mount system stiffness on air and ground resonance stability, and if not important, variations in the system may be omitted from the test program. *

(3) The probable ranges of damping shall be established and investigated as prescribed and noted in paragraph (b) of § 29.633. An approved test proposal and test results report should be used for complying with § 29.663(b). For example, if a conventional wheel landing gear is used on the rotorcraft, the probable ranges of tire pressure or the lowest probable tire pressure should be stated in the test proposal and effects of the tire pressure investigated during the test. In addition, the effects of strut pressures should be investigated also. See paragraph 99, § 29.241, concerning tests and instrumentation of the test associated with complying with § 29.241. The instrumentation noted in paragraph 99 also applies to § 29.663(b).

(4) If the wheel landing gear is equipped with wheel brakes, the evaluation should include brakes "on" and "off." The nose or tail wheel should be locked and unlocked if it swivels to evaluate any possible adverse effects of this feature. *

269.-275. RESERVED.

U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: CERTIFICATION OF TRANSPORT CATEGORY ROTORCRAFT	**Date:** 9/24/91 **Initiated by:** ASW-110	**AC No:** 29-2A **Change:** 2

1. PURPOSE: This change revises existing material in 17 paragraphs and adds new material for 41 paragraphs previously shown as "RESERVED."

   The change number and date of the changed material are carried at the top of each page. The asterisks (*) in the right and left margins indicate the beginning and end of each change. Rearranged pages having no new material also carry the change number and new date. Pages having no changes retain the same heading information. In paragraphs that are entirely new, asterisks (*) appear only in the margins at the beginning and the end of each new page. In addition, several paragraphs were renumbered for better continuity between AC's 27-1 and 29-2A.

2. PRINCIPAL CHANGES.

   a. Paragraphs 72, 80, 141, 206, 245, 268, 304, 373, 498, 621, 637, 656, 726, 748, 775, 776, and 786 are revised.

   b. New paragraphs 87, 302, 303, 305, 316, 317, 318, 319, 330, 343, 347, 360, 449, 462, 549, 550, 562, 567, 568, 569, 570, 584, 585, 586, 587, 588, 589, 591, 592, 593, 594, 595, 596, 703, 705, 707, 708, 718, 725, and 785 are added to Chapter 2.

   c. New paragraph 788 is added to Chapter 3.

   d. Paragraphs listed below have had the paragraph numbers changed.

Existing Numbers	New Numbers
707 (Proposed)	708
708 (Proposed)	707

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
III	4/24/89	III thru XIV	9/24/91
IV	9/16/87		
V thru XII	4/24/89		
XIII	9/16/89		
XIV	4/24/89		
135 thru 138	9/16/87	135 thru 137	9/24/91
		138	9/16/87
149 thru 152	9/16/87	149	9/16/87
		150 thru 152	9/24/91
163 and 164 (thru 174)	9/16/87	163	9/16/87
		164 (thru 174)	9/24/91
237 thru 250	9/16/87	237	9/16/87
		238 thru 240 (thru 248)	9/24/91
		249	9/24/91
		250	9/16/87
317 and 318	4/24/89	317	9/24/91
		318	4/24/89
387 and 388 (thru 398)	4/24/89	387	9/24/91
		388 (thru 398)	4/24/89
411 thru 432	9/16/87	411	9/16/87
		412 thru 416 (thru 432)	9/24/91
491	4/24/89	491	4/28/89
492 (thru 498)	9/16/87	492 thru 504 (thru 530)	9/24/91
499 thru 500 (thru 530)	9/16/87		
537 and 538 (thru 540)	4/24/89	537 thru 540	9/24/91
573 and 574 (thru 578)	9/16/87	573	9/24/91
		574 (thru 578)	9/16/87
581 and (thru 596)	9/16/87	581 thru 584 (thru 596)	9/24/91
599 and 600 (thru 602)	9/16/87	599	9/16/87
		600 thru 602-2	9/24/91
607	9/16/87	607 thru 620 (thru 634)	9/24/91
608 (thru 634)	4/24/89		
707	9/16/87	707	9/16/87
708	4/24/89	708 and 708-1 (and 708-2)	9/24/91
751 and 752 (thru 770)	4/24/89	751	4/24/89
		752 thru 754 (thru 770)	9/24/91
789 and 790	9/16/87	789	9/24/91
		790	9/16/87
881 and 882 (thru 888)	4/24/89	881	4/24/89
		882 thru 886 (thru 888)	9/24/91
889 and 890 (thru 900)	4/24/89	889	4/24/89
		890 (thru 900)	9/24/91
903 and 904 (thru 940)	4/24/89	903	4/24/89
		904 thru 906 (thru 920)	9/24/91
		921 thru 930 (thru 940)	9/24/91

where, V_S = vertical speed ft/sec, derived from § 29.725(a)
K_y = pitching radius of gyration - ft. from pitching axis
l_b = distance from most critical c.g. location to the guard or bumper contact point - ft.
W = gross weight less rotor lift from § 29.473(a) - lbs.
g = 32.2 ft./sec.^{2}

(ii) Other, more recent, analytical techniques (most utilizing computer programs) may, of course, be used rather than the ANC-2a means after proper substantiation for applicability and validity.

(iii) The tail rotor guard shall not fail when the limit and ultimate load, which is derived from a combination of the limit kinetic energy and the guard resulting limit deflection required to dissipate the energy, is imposed on the guard and the helicopter tail (see § 29.305).

(3) Substantiation of the guard, skid, or bumper for the design loads derived may be accomplished by test or analysis as stated in § 29.307(a).

(4) Several rotorcraft tail rotor guards are installed solely for the protection of ground personnel from the rotating tail rotor. For guards installed for this purpose, the applicant should use prudent and reasonable design loads and features. Such guards should not present a hazard to the helicopter because of its design features.

* 159. <u>§ 29.413 (through Amendment 29-19) STABILIZING AND CONTROL SURFACES</u>.

a. <u>Explanation</u>. Minimum design loads are specified for stabilizing as well as control surfaces.

(1) Paragraph (a) of the rule requires application of minimum empirical design loads, application of critical maneuvering loads, and application of critical maneuvering loads combined with vertical or horizontal gust loads (30 feet per second per § 29.341).

(2) Paragraph (b) requires load distributions that closely simulate actual pressure distributions. Both spanwise and chordwise distributions are intended.

(3) These surfaces are used for stability and control thereby hopefully extending the c.g. range and increasing the airspeed of modern designs.

(4) To "closely simulate actual pressure condition" on the surfaces, unsymmetrical loads are also required on horizontal surfaces. An arbitrary distribution, if conservative, may be used.

(5) It is noted § 29.571 requires fatigue substantiation of the flight structure which will include control and stabilizing surfaces.

(6) If the surface is controllable, a proof and operation test of the surface control system is required by §§ 29.681 and 29.683. *

* b. Procedures. Modern rotorcraft designs have generally employed a fixed or a wholly movable, not split or divided, stabilizing or control surface.

(1) Design Loads.

(i) Limit loads of 15 pounds per square foot will apply up to approximately 90-knot design airspeed. Above 90 knots design airspeed (V_d), the coefficient (C_N = 0.55) imposes higher limit loads on the surface.

(ii) In addition, combined maneuvering and gust loads may impose the highest limit loads on the control surfaces of helicopters. This is attributed to the increase in speed (horizontal gust) and to the change in angle of attack and change in airspeed (vertical gust). Imposing the horizontal gust (30 feet per second or 17.8 knots) on the surface in combination with 130-knot design speed results in a 30 percent increase in the design load. The gust conditions cause a significant increase in design loads due to a change in angle of attack, with a change in resultant airspeed, or due to the increase in airspeed.

(iii) The applicant may choose to derive the limit loads using maximum aerodynamic coefficients for the surface under consideration at the maximum design airspeed combined with a 17.8-knot gust. This would be acceptable provided these design loads exceed the minimum loads derived from a C_N = 0.55 at design airspeed or exceed 15 pounds per square foot load on the surface.

(2) The load distribution on the surface should closely simulate actual pressure distributions.

(i) The spanwise load may be rectangular or other acceptable conservative distributions may be used. The method developed by O. Schrenk in NACA TM 948, 1940, is an acceptable method for approximation of spanwise distribution.

NOTE: The method is valid for aspect ratios of 5 to 12 and for rectangular planforms such as used on rotorcraft, other planforms may be acceptable as prescribed in the TM.

(ii) The chordwise distribution appropriate for the aerodynamic shape should be used.

(iii) The flight load survey conducted under § 29.571 may be used to confirm design parameters and possible load distribution data. On controllable surfaces, the pitching moment (control loads) is measured for fatigue substantiation of the control system. The control stabilizing surfaces are subject to loads measurement and possible fatigue tests for fatigue substantiation also.

(3) Proof of the structure for the required loads is specified in §§ 29.301, 29.303, 29.305, and 29.307. Tests or analysis may be used as prescribed. If analysis is used, fitting factors and other appropriate factors prescribed by the rules of §§ 29.625, 29.621, and 29.623 will be required in the analysis. *

160.-169. RESERVED.

SECTION 10. GROUND LOADS

* 170. § 29.471 (through Amendment 29-19) GENERAL.

a. Explanation. This regulation specifies that limit ground loads must be considered which are:

(1) External loads caused by landing (ground) conditions and by ground taxiing loads as specified in § 29.235.

(2) Loads considering the rotorcraft structure as a rigid body.

(3) Loads in equilibrium with linear and angular inertia loads.

(4) The critical center of gravity "must be selected so that the maximum design loads are obtained in each landing gear element."

b. Procedures.

(1) The standards to be considered are specified in §§ 29.473 through 29.511. These associated standards cover landing gear arrangements, landing conditions, and ground handling conditions.

(2) Drop tests are required for determination of landing load factors. See paragraph 298 of this document.

(3) The application of the design loads derived from the landing load factors will be as specified for each element affected by landing or ground handling loads.

(4) During the applicant's flight test program, the ground, landing, and taxiing load factors may be monitored to assure the design load factors used are adequate. See paragraph 97 of this document for § 29.235 policy.

171. § 29.473 (through Amendment 29-19) GROUND LOADING CONDITIONS AND ASSUMPTIONS.

a. Explanation. The rotorcraft is to be designed for the maximum weight. A rotor lift of two-thirds of the design maximum weight may be used. The minimum limit landing load factor is determined by the drop tests of § 29.725. Provisions are made for supplementary energy absorption devices that have triggering mechanisms.

b. Procedures. Loads for the landing conditions are derived considering mass (equal to the maximum weight) and rotor lift (equal to two-thirds of the maximum weight) acting through the center of gravity throughout the landing impact. Unbalanced external loads resulting from asymmetric loading conditions are reacted as specified in the individual subparagraphs.

* NOTE: If supplementary energy absorption devices are used, neither they nor their triggering devices may fail under the loads established by the limit drop tests or the reserve energy absorption drop tests.

172. § 29.475 (through Amendment 29-19) TIRES AND SHOCK ABSORBERS.

a. Explanation. This section specifies the tire and shock absorber position to be used in ground load derivations.

b. Procedures. Ground loads are to be derived with the tires in static (1g) position and the shock absorbers "in their most critical position." The determination of the "most critical position" for the shock absorbers generally requires a load versus deflection test or analysis of the shock absorber system and a determination of the effect of both load and deflections on the shock absorber, attachment structure, and substructure designed by ground loads.

173. § 29.477 (through Amendment 29-19) LANDING GEAR ARRANGEMENT.

a. Explanation. This section specifies the individual standards to be used for ground load conditions for helicopters having two wheels aft and one or more wheels forward of the center of gravity.

NOTE: § 29.497 gives ground loading conditions for landing gear with tail wheels, and § 29.501 gives ground loading conditions for landing gear with skids.

b. Procedures. The ground loading conditions of §§ 29.235, 29.479 through 29.485, and 29.493 will be used for helicopters having two wheels aft and one or more wheels forward of the center of gravity. This includes forward wheels on separate axles.

174. § 29.479 (through Amendment 29-19) LEVEL LANDING CONDITIONS.

a. Explanation. This section provides explicit level landing load criteria for landing gear with two wheels aft and one or more wheels forward of the center of gravity.

(1) Level landings--

(i) Each wheel contacting the ground simultaneously; and

(ii) Aft wheels contacting the ground with forward wheels just clear of the ground. *

(2) Application of loads--

(i) Maximum design vertical loads applied alone;

(ii) The maximum design vertical loads applied with a drag load of at least 25 percent of the vertical load (applied at the ground contact area); and

(iii) The vertical load at the instant of peak drag load in conjunction with the peak drag load. A ground speed and load application is specified.

(3) A 40 percent/60 percent load distribution between wheels for configurations having two forward wheels including quadricycle. This distribution between wheels on a common axis is to be applied for the conditions of vertical loads only, and for vertical loads combined with drag loads of 25 percent of the vertical loads. Section 29.511 concerns a 60 percent to 40 percent ground load distribution between multiple-wheel units. See paragraph No. 182 of this document for dual wheels on a common axle or axis.

(4) Aircraft pitching moments are to be reacted by the forward landing gear or by the angular inertia forces when the forward landing gear is clear of the ground as specified.

b. Procedures.

(1) The specified loading conditions will be used in load derivations.

(2) The critical center of gravity condition will be used for each gear and gear support structure.

(i) The aft center of gravity condition with the forward gear clear will normally be critical for the aft gear and gear supports.

(ii) The forward center of gravity condition with each gear contacting the ground simultaneously will normally design forward gear elements critical for vertical loads.

(iii) The forward center of gravity condition with the forward gear clear may result in high load factors, angular plus linear, that will greatly affect security of items of significant mass.

(3) The vertical load, at the instant of peak drag load combined with the peak drag component, can be determined from drop tests utilizing wheel spin-up or it can be analytically determined. If analysis is used, it must successfully correlate with the results of a previous well-instrumented test program.

* 175. § 29.481 (through Amendment 29-19) TAIL-DOWN LANDING CONDITIONS.

a. Explanation. This section provides the criteria for tail-down landing conditions, i.e., "the maximum nose-up attitude allowing ground clearance" with ground loads acting "perpendicular to the ground."

b. Procedures.

(1) The tail-down landing condition will be used to check (by analysis or test) for criticality of landing gear or support structure. This attitude generally creates the highest forward loads on the landing gear in combination with vertical loads.

(2) The tail-down landing condition may be the critical condition for both landing load factor and for energy absorbtion by the main gear. Section 29.725 requires that "each landing gear must be tested in the attitude simulating the landing condition that is most critical." Where questions exist as to the critical attitude, both level landing and tail-down landing attitudes should be used in drop tests required by § 29.725.

176. § 29.483 (through Amendment 29-19) ONE-WHEEL LANDING CONDITIONS.

a. Explanation. This section gives the condition to be used for one-wheel landing conditions. Only the vertical load condition of § 29.479(b)(1) is required.

b. Procedures. The one-wheel landing condition is generally critical for the landing gear-to-fuselage attachments and the landing gear elements between the attachments. Unbalanced external loads are reacted by rotorcraft inertia. Large items of mass located radially from the center of gravity (aircraft centerline may be used) should also be structurally substantiated for the combined rolling (angular) and linear accelerations of this loading condition.

177. § 29.485 (through Amendment 29-19) LATERAL DRIFT LANDING CONDITIONS.

a. Explanation.

(1) This section provides the loading conditions which impose side (and vertical) loads on the landing gear. A level landing attitude is specified. Two main conditions required are--

(i) Only the aft wheels in contact with the ground; and

(ii) All wheels contacting the ground simultaneously. *

(2) Loads. The vertical loads to be applied with the side loads are specified as "one-half of the maximum ground reactions of § 29.479(b)(1)." These vertical loads are the level landing loads considering both contact and noncontact with the ground by the forward wheels.

(i) One side load condition is specified as "0.8 times the vertical reaction acting inward on one side and 0.6 times the vertical reaction acting outward on the other side" when only the aft wheels contact the ground.

(ii) The other side load condition (for all wheels contacting the ground) specifies the 80 percent inward/60 percent outward distribution for the aft wheels and 0.8 times (80 percent) the vertical reaction for the forward wheels.

b. Procedures. The loading conditions, as specified, are applied to the landing gear and attaching structure. The loads are applied at the ground contact point, except for full swiveling gear which has the load applied at the center of the axle. In other words, full swiveling gear is considered to have swiveled to a static position under the side load before the design vertical and side loads are achieved. The landing gear backup structure, as well as the landing gear itself, will be substantiated for these side load conditions.

178. § 29.493 (through Amendment 29-19) BRAKED ROLL CONDITIONS.

a. Explanation. This section provides two loading conditions for ground braking operations. Specific vertical loads in conjunction with drag loads (due to braking) are to be considered. The limit vertical load factor is 1.33 for condition of all wheels in contact with the ground, and 1.0 for condition of aft wheels only in contact with the ground and nose wheel clear. The drag load on wheels with brakes is 0.8 times the vertical load or the drag load value based on limiting brake torque, whichever is less.

b. Procedures. The braking loads are calculated from the specified criteria with the shock absorbers in their static (normal) positions and with the drag loads applied at the ground contact point. Structural substantiation of the affected structure may be accomplished by test or analysis. If tests are used, the wheel and tire assembly is commonly replaced with a test fixture so the limit loads and static deflections specified can be more accurately controlled. The test specimen should be complete enough to assure that the landing gear structure and the attach and backup structure are adequately substantiated.

* 179. § 29.497 (through Amendment 29-19) GROUND LOADING CONDITIONS: LANDING GEAR WITH TAIL WHEELS.

a. Explanation. This section provides the loading conditions for landing gear designs with tail wheels.

(1) Level landings are to consider the following:

(i) All wheels (main and tail) contacting the ground simultaneously, as well as only forward main wheels contacting the ground.

(ii) Maximum design vertical loads applied alone.

(iii) The maximum design vertical loads combined with a drag load of at least 25 percent of the vertical loads for both conditions.

(2) Noseup landings with only the rear wheel or wheels initially contacting the ground must be considered unless shown to be extremely remote.

(3) Level landings on one forward wheel only are to be considered. Drag loads are not required.

(4) Side load conditions are imposed on the main wheels and tail wheels for level landing attitudes. Criteria for full swiveling and locked tail wheels are included in this standard.

(5) Braked roll conditions are specified for the level landing attitudes.

(6) Rear wheel turning loads are also specified for swiveling and locked tail wheels.

(7) Taxiway condition loads for the landing gear and rotorcraft are those that "occur when the rotorcraft is taxied over the roughest ground that may reasonably be expected in normal operation." The aircraft design load factors should not be exceeded during the evaluation. Section 29.235 contains an identical standard that applies to all types of wheel landing gear.

b. Procedures.

(1) The specified loading conditions are to be used in load derivations.

(2) The critical center of gravity condition is used for each gear and gear support structure.

(i) The forward center of gravity condition with the tail gear clear will normally be critical for the forward gear and gear supports.

(ii) The aft center of gravity condition with the tail gear clear should be checked for criticality of security of large mass items located forward of the center of gravity Vertical and angular accelerations are additive under this landing condition.

(iii) The aft center of gravity condition with each gear contacting the ground simultaneously will generally design tail gear elements critical for vertical loads. The other conditions are generally less severe but must be proven.

(3) For noseup landing procedures use § 29.481. The reference to "extremely remote" in § 29.497(d)(2) predates current §§ 25.1309, 29.1309, and AC 25.1309.1. This phrase has been used to require consideration of noseup landings unless features of design are present which prevent noseup landings or where such landings are unlikely during the life of the rotorcraft. See paragraph No. 175 of this document.

(4) Use § 29.483 for one-wheel landing procedures, paragraph No. 176 of this document.

(5) Use § 29.485 procedures for side load conditions, paragraph No. 177 of this document.

(6) Use § 29.493 procedures for braked roll conditions, paragraph No. 178 of this document.

(7) For rear wheel turning loads, swiveling of tail landing gears is allowed as in basic side load conditions. The side load is applied at the axle, or if the wheel is locked, the load is applied at ground contact. Rear wheels are loaded with the critical vertical static load in conjunction with an equal side load to substantiate the tail gear.

(8) Since the rotorcraft is to be designed for load factors that will not be exceeded during taxi tests or other conditions, an instrumented taxi test program will be necessary. Use § 29.235, paragraph No. 97, of this document.

180. <u>§ 29.501 (through Amendment 29-19) GROUND LOADING CONDITIONS: LANDING GEAR WITH SKIDS</u>.

a. <u>Explanation</u>. This section provides the ground loading conditions for landing gear with skids. The loading conditions are similar to those for wheeled gear except for the following criteria which are unique to skid gears:

(1) Structural yielding (plastic deformation) of elastic spring members under limit loads is allowed.

* (2) Design ultimate loads for elastic spring members need not exceed the loads obtained in a drop test with a drop height of 1.5 times the limit drop height. The rotorcraft and the landing gear attachments are subject to the prescribed design ultimate loads.

(3) The gear must be in its most critically deflected position (similar to § 29.475).

(4) Ground reactions are rationally distributed along the bottom of the skid unless otherwise specified. Paragraph (f) concerns specific "concentrated" and arbitrary load conditions.

(5) Drag loads are 50 percent of vertical reactions rather than the 25 percent for wheeled gear.

(6) Side loads are 25 percent of the total vertical reaction rather than the 60-80 percent for wheeled gear.

(7) Side loads are applied to one skid only (inward acting and outward acting) with resulting unbalanced moment resisted by angular acceleration.

(8) A ground reaction load of 1.33 times the maximum weight is to be applied at 45 degrees from the horizontal axis:

(i) Distributed among or between the skids;

(ii) Concentrated at the forward end of the straight portion of the skid tube; and

(iii) Applied only to the forward end of the skid tube and its attachment to the rotorcraft.

(9) A concentrated vertical load equal to one-half of the design limit vertical load is to be applied at a point midway between the skid tube attachments.

b. Procedures.

(1) The specified loading conditions are to be used in load derivations.

(2) The critical center of gravity conditions are to be used for each gear and gear support structure. Asymmetry of the skid tubes, cross tubes, and gear attachments are to be considered in determining the critical center of gravity condition. *

(3) The rotorcraft and landing gear attachment must be substantiated for ultimate landing loads by either test or analysis utilizing an ultimate load factor of 1.5 in accordance with § 29.303. The elastic spring members may be analyzed or static tested for ultimate loads (and deflections) using either a factor of safety of 1.5 or one associated with an "ultimate" drop height of 1.5 times the limit drop height. Substantiation by "ultimate" drop tests may be used provided all combinations of critical parameters are included in the total substantiation effort. This method will require a series of tests using several test specimens, or a limited number of drop tests plus further substantiations by static tests or analyses for additional critical conditions not covered by the drop test(s).

181. § 29.505 (through Amendment 29-19) SKI LANDING CONDITIONS.

a. Explanation. This is an optional requirement for ski operations. The regulation specifies vertical loads, side loads, and torque loads (Mz) to be applied to ski installations. The four loading conditions to be applied at the pedestal bearings are:

(1) Simultaneous application of Pn, up load, and Pn/4, horizontal load.

(2) Up load of 1.33 P.

(3) Side load of 0.35 Pn.

(4) Torque load of 1.33 P (in foot-pounds), about vertical axis through centerline of the pedestal bearings.

NOTE: Where P is the maximum static weight on each ski and n is the limit load factor obtained from drop tests. The load factor obtained from wheel or skid landing gear drop tests may be used.

b. Procedures. Structural substantiation may be accomplished by static test or analysis using the specified loads. Skis generally have a limit load rating. The design loads derived for this standard must not exceed the rating. See § 29.737, paragraph No. 305, for information on ski design standards. TSO-c28 concerns, in part, standards for aircraft skis. *

* 182. § 29.511 (through Amendment 29-19) GROUND LOAD: UNSYMMETRICAL LOADS ON MULTIPLE-WHEEL UNITS.

a. Explanation. Two loading conditions are provided to account for unsymmetrical loads on multiple-wheel units due to landing and normal operations over crowned runways and taxiways and to account for deflated tires. They are:

(1) Sixty percent of total ground reaction applied to one wheel of a dual wheel unit and 40 percent to the other.

(2) Sixty percent of the "specified load for the gear unit" is applied to the wheel with an inflated tire when the other tire is deflated (the 60 percent load may not be less than the 1g static load).

NOTE: The 60:40 distribution also applies to nose wheel units as noted in § 29.479(b)(4).

b. Procedures. Structural substantiation may be accomplished by static test or analysis using the specified load. As provided by the standard, the total load on the gear units may neglect the transverse shift of the load centroid due to unsymmetrical load distribution; i.e., the external load for each gear may be calculated considering the same load centroid as with symmetrical wheel loads, and then the external load for each gear is divided in accordance with the distributions of § 29.511(a) and (b) between the wheels.

183.-192. RESERVED.

SECTION 11. WATER LOADS

193. § 29.519 HULL TYPE ROTORCRAFT: WATER BASED AMPHIBIAN AND LIMITED AMPHIBIAN. (RESERVED)

194. § 29.521 FLOAT LANDING CONDITIONS. (RESERVED)

195.-204. RESERVED.

SECTION 12. MAIN COMPONENT REQUIREMENTS

* 205. § 29.547 (through Amendment 29-19) MAIN ROTOR STRUCTURE.

a. Explanation. This regulation requires the main rotor structure to be designed to the static load requirements of §§ 29.337 through 29.351 (vertical maneuvering loads, vertical and horizontal gust loads, and yawing maneuver loads). In addition, the main rotor blades, hubs, and flapping hinges are specified to be designed for impact forces of each blade against its stop during ground operation and for specified limit torque at any rotational speed including zero. The torque forces (from the drive system) are distributed to the rotor blades as specified.

b. Procedures.

(1) Substantiation in compliance with this standard is accomplished by application of the flight loads of §§ 29.337 through 29.351 and the torque loads of § 29.361 to the rotor structure by stress analyses and/or static tests. The use of wind tunnel data as well as flight loads survey data may be used to generate and/or check the external load magnitudes and distributions.

(2) Where new materials are used in the main rotor structure, such as composites containing plastics, the effects of temperature and humidity are to be considered in accordance with § 29.603, and the effects of uncertainties in manufacturing processes or inspection methods are to be considered in accordance with § 29.619.

(3) The design impact forces of each blade must be imposed against its stop or stops. Appropriate monitoring of the blades, hubs, flapping hinges, and stops during laboratory tests, ground endurance tests, and flight tests should ensure that the stops are sufficient for ground operation loads. The design torque loads are derived as prescribed.

206. § 29.549 (through Amendment 29-19) FUSELAGE AND ROTOR PYLON.

a. Explanation. This regulation requires that the fuselage and rotor pylon (including the tail fin, if any) be designed to withstand the flight loads of §§ 29.337 through 29.351, the ground loads of §§ 29.235, 29.471 through 29.497, ski loads of § 29.505, water loads of § 29.521, and rotor loads of § 29.547(d)(1) and (e)(1)(i). The ski and water loads pertain to optional features.

(1) Consideration is also required of--

(i) Auxiliary rotor thrust;

(ii) The torque reaction of each rotor drive system; and

(iii) Balancing air and inertia loads.

* (2) Each engine mount and adjacent fuselage must be substantiated as prescribed. In addition, if 2 1/2-minute power is used, "each engine mount and adjacent structure must be designed to withstand the loads resulting from a limit torque equal to 1.25 times the mean torque for 2 1/2-minute power combined with 1g flight loads."

b. Procedures. Compliance with this standard is accomplished by application of the specified aircraft loads including engine torque to the fuselage and rotor pylon structure by stress analyses and/or static tests. Drive system torque factors to be used are noted in § 29.547 for the main rotor structure as well as in paragraph (e) of this standard.

207. § 29.551 (through Amendment 29-19) AUXILIARY LIFTING SURFACES.

a. Explanation. This regulation specifies that auxiliary lifting surfaces be designed to withstand critical flight and ground loads derived for conditions specified and any "other critical condition expected in normal operation." Stub wings would comply with this standard.

b. Procedures. The surface design loads are derived from the conditions specified. Conservative aerodynamic data, including load distributions, may be used in place of data derived from wind tunnel or instrumented flight testing of the exact aerodynamic shapes involved. Special attention should be placed on concentrated load effects from fuel tanks or other large mass items that may be located in lifting surfaces. These types of load concentrations are to be considered in conjunction with inertia and aerodynamic loads.

208.-217. RESERVED.

SECTION 13. EMERGENCY LANDING CONDITIONS

218. § 29.561 GENERAL (RESERVED)

219. § 29.563 (through Amendment 29-19) STRUCTURAL DITCHING PROVISION.

a. Explanation. Amendment 29-12 included certification requirements for ditching approvals. The helicopters must be able to sustain an emergency landing in water as prescribed by § 29.801(e).

b. Procedures. Refer to paragraph 337, § 29.801, for procedures.

220.-229. RESERVED.

* 251. § 29.625 (through Amendment 29-19) FITTING FACTORS.

a. Explanation. A 1.15 factor is specified to assure that the calculated load and stress distribution within any fitting is conservative. Application of the factor is excluded or excepted as stated in the rule.

b. Procedures.

(1) The factor may be applied to the calculated load or stress for the fitting.

(2) The structural substantiating data for the rotorcraft, including the rotor system, must include the prescribed fitting factor. The rotor system includes the flight control system rotor head and hubs and rotor blade attachments.

252. § 29.629 (through Amendment 29-19) FLUTTER.

a. Explanation.

(1) The rotorcraft must be free from flutter.

(2) Section 29.251 vibration is an associated flight requirement concerning flight demonstrations. See paragraph 110 of this document for this standard.

(3) Section 29.571(a)(3) concerns in-flight measurement of loads or stresses.

b. Procedures.

(1) Freedom from flutter may be shown by analysis or appropriately instrumented flight flutter tests.

(2) The flight loads survey proposal submitted for compliance with § 29.571 may also contain tests to fulfill compliance with § 29.629. The flight loads survey program encompasses the envelope of design airspeed and rotor r.p.m., and sufficient aerodynamic excitation is generally present to excite any latent flutter modes.

(3) Flight loads survey data or flight flutter test data submitted should be reviewed to assure that excessive oscillatory loads of rotors or surfaces will not be encountered. *

253.-264. RESERVED.

SECTION 16 ROTORS

265. § 29.653 PRESSURE VENTING AND DRAINING OF ROTOR BLADES. (RESERVED)

266. § 29.659 MASS BALANCE. (RESERVED)

* 267. § 29.661 (through Amendment 29-19) ROTOR BLADE CLEARANCE.

a. Explanation.

(1) The rotors, main and tail, must not strike other parts of the rotorcraft during any operating condition.

(2) Section 29.411 concerns protection of the tail rotor from a ground strike.

b. Procedures.

(1) The applicant should have drawings or sketches of the rotorcraft that show an adequate minimum clearance between the rotors, main and tail, and parts of the rotorcraft. Probable flexing of the rotors should be considered in determining the minimum clearance.

(2) During parts of the FAA-conducted flight test program, frangible devices (wood dowels) or other means of measuring clearance, may be requested to confirm that the clearance shown in the drawings or sketches is adequate in certain operating conditions. Balsa wood dowels may be clamped to the aft part of the fuselage within the rotor arc. If the devices are intact after autorotation landing tests and other tests involving typical abrupt, cyclic, and rudder pedal displacements, the clearance should be satisfactory and compliance obtained. If such measuring devices are used, the type inspection report should contain a record of clearance found during the tests. It is not necessary to precisely determine the clearance but only necessary to determine "enough clearance" as stated in the rule.

268. § 29.663 (through Amendment 29-19) GROUND RESONANCE PREVENTION MEANS.

a. Explanation.

(1) This rule, adopted in Amendment 29-3, requires reliability and damping action investigation for the ground resonance prevention means and requires associated maintenance information in the maintenance manual (§ 29.1529). The probable range of variations in service, not just the allowable range, must be investigated as prescribed. This probable range includes operation on the ground, water, or other appropriate landing surface applicable to the rotorcraft design. Quantitative test data are generally obtained in compliance with this rule. See the preamble to Amendment 29-3 for further information.

(2) Note that the maintenance information is not contained in the approved section of the maintenance manual. *

(3) Paragraph 99 concerns demonstrating freedom from ground resonance during certain applicant and TIA verification evaluations or tests of the rotorcraft. Section 29.241 complements the requirements of § 29.663. As noted in paragraph 99 of this document, the FAA removed from CFR Part 7 a specific requirement for a ground vibration survey. However, § 29.663 was adopted by Amendment 29-3 to investigate possible sources of ground resonance and to assure the reliability of the ground resonance prevention means; i.e., dampers to preclude occurrance of ground resonance. The total rotorcraft system is evaluated under this rule.

(4) Viscous dampers have been used for many years to prevent ground resonance. Modern rotorcraft designs may also use elastomeric dampers and may use elastomeric bearings in the rotor head and rotor pylon attachment to the airframe. The rule also requires investigation of the probable range of variations of these dampers and bearings to preclude ground resonance.

(5) Ground resonance can occur due to flexibility in the rotor pylon restraint system as well as with landing gear flexibilities. This evaluation should include variations in stiffness and damping of the rotor pylon restraints that may occur in service (reference "Ground Vibrations of Helicopters," M. L. Deutsch, JAS, Vol. 13, No. 5, May 1946).

b. Procedures.

(1) The reliability of the means for preventing ground resonance may be substantiated as stated in the rule. An analysis report or a test proposal and subsequent test report may be used to show compliance. The probable ranges of damping restriction are an important part of the assessment. The test may be conducted in conjunction with the testing required by § 29.241. See paragraph 99.

(i) Analysis and tests may be used;

(ii) Reliable service history of identical or closely similar systems may be used. The materials and fluids used, clearance or fits, seals, and physical installation are important items to be evaluated and considered for "closely similar" systems;

(iii) Testing of the complete rotorcraft may be used to prove that malfunction of a single means of the damping system will not cause ground resonance. One method of demonstrating acceptable compliance is by removing all seals from one damper, in conjunction with considering the allowable ranges of damping of the other parts of the rotorcraft damping system and operating the rotorcraft throughout the rotor speed range from start to maximum rotor speed. The rotorcraft cyclic control should be displaced as noted in paragraph 99 of this document to assure that the possible rotorcraft resonance frequencies are excited. If vibrations are damped in all tests, the damping system is satisfactory. Each critical rotor damper and landing gear damper must simulate a malfunction to comply with the rule. The testing discussed, however, could *

* become very extensive if one were to attempt to test all combinations of all maintenance adjustments of all components which contribute to the prevention of ground resonance, while at the same time rendering each of the pertinent components ineffective in turn and then repeating all of the maintenance tolerance testing each time. Fortunately, rational analytical methods are available which will permit the evaluation of such combinations so that only the combinations with the least amount of margin used are physically tested.

(2) The probable ranges of damping must be investigated as prescribed and noted in subparagraph a(1). An approved test proposal and test results report should be used for complying with § 29.663(b). If wheel landing gear is used on the rotorcraft, the probable ranges of tire pressure or the lowest probable tire pressure should be stated in the test proposal and effects of the tire pressure investigated during the test. See paragraph 99, § 29.241, concerning tests and instrumentation of the test associated with complying with § 29.241. The instrumentation noted in paragraph 99 also applies to § 29.663(b).

(3) If the wheel landing gear is equipped with wheel brakes, the evaluation should include brakes "on" and "off." The nose or tail wheel should be locked and unlocked if it swivels to evaluate any possible adverse effects of this feature. *

269.-278. RESERVED.

SECTION 17. CONTROL SYSTEMS

279. § 29.671 GENERAL. (RESERVED)

280. § 29.675 STOPS. (RESERVED)

281. § 29.679 CONTROL SYSTEM LOCKS. (RESERVED)

282. § 29.681 LIMIT LOAD STATIC TESTS. (RESERVED)

283. § 29.683 OPERATION TESTS. (RESERVED)

284. § 29.685 CONTROL SYSTEM DETAILS. (RESERVED)

285. § 29.687 SPRING DEVICES. (RESERVED)

(3) The required "down-lock" should be checked during the operation test. The design drawing should be reviewed for compliance prior to conducting an operation test.

(4) If an optional "up-lock" is installed, the landing gear should be extended during the operation test after simulation of critical failure mode of the retraction system.

(5) An "operation" test plan or proposal submitted for compliance with § 29.729(d) should include the items noted in the two previous subparagraphs and should include a functional check of the position indicator system. Those tests must be satisfactorily completed before issuing the TIA.

(6) During the official FAA flight tests, compliance with the emergency operation, position indicator, and control aspect of § 29.729(c), (e), and (f), respectively, will be verified or accomplished. In addition, the F and R test program plan (§ 21.35) will specify certain tests or evaluations for the retraction system.

(7) Position Indicator Evaluation.

(i) When evaluating the position indicator system, emphasis should be placed on the switches and their installations, and on the cockpit presentation. Each gear must have its own set of switches to indicate when it is secured in its extreme "up" position and its extreme "down" position. The switches must be located to give a valid indication of the arrival of the gear at its extreme position.

(ii) The reliability and environmental qualifications of the switches to be used should be carefully considered. An example of a condition that has potential for trouble is operation on wet areas. Trouble starts when water is picked up by the tires and deposited on the switches. During winter months the water can freeze, and the resulting ice may prevent the switch from functioning properly.

(iii) An acceptable cockpit presentation consists of two lights for each gear. One light is colored "green" and indicates when its gear is secured in the extreme "down" position. The other light is colored "amber" and indicates when its gear is in transit. When the gear is in either extreme position, the in transit light is "out." For this presentation the indication to the pilot that the gear is in the extreme "up" position is an all-gear lights-out condition.

(iv) Some manufacturers have also included a warning system to alert the crew if the landing gear has not been extended prior to landing. If a warning system is presented, §§ 29.1301 and 29.1309 should be used to evaluate its functional characteristics and the impact of its failure modes.

302. § 29.731 WHEELS. (RESERVED)

303. § 29.733 TIRES. (RESERVED)

304. § 29.735 BRAKES. (RESERVED)

305. § 29.737 SKIS. (RESERVED)

306.-315. RESERVED.

SECTION 19. FLOATS AND HULLS

316. § 29.751 MAIN FLOAT BUOYANCY. (RESERVED)

317. § 29.753 MAIN FLOAT DESIGN. (RESERVED)

318. § 29.755 HULL BUOYANCY. (RESERVED)

319. § 29.757 HULL AND AUXILIARY FLOAT STRENGTH. (RESERVED)

320.-329. RESERVED.

SECTION 20. PERSONNEL AND CARGO ACCOMMODATIONS

330. § 29.771 PILOT COMPARTMENT. (RESERVED)

331. § 29.773 PILOT COMPARTMENT VIEW. (RESERVED)

* 332. § 29.775 (through Amendment 29-19) WINDSHIELD AND WINDOWS.

a. Explanation. Nonsplintering safety glass is required in windshields and windows containing glass to protect crew and passengers in the event that window fracturing occurs.

b. Procedures. Use nonsplintering safety glass in windshield or window applications which contain glass rather than plastic acrylics, polycarbonates, epoxys, etc. The glass selected must meet a specification such as MIL-G-25871, and if new vendors are selected by an airframe manufacturer, test data should be obtained from the vendor to demonstrate the safety glass provided meets an acceptable specification and provides adequate nonsplintering capability. •

333. § 29.777 COCKPIT CONTROLS. (RESERVED)

* 334. § 29.783 (through Amendment 29-20) DOORS.

a. Explanation. This regulation requires at least one door for all closed cabin rotorcraft. Standards for all doors and airstair doors are included. To assure that the doors provide normal entry and egress without causing or contributing to hazardous conditions, even after a minor crash, the following requirements are imposed:

(1) Passenger doors may not be located with respect to any rotor to endanger persons using the doors as instructed.

(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 (ref. § 29.783(c)) with the device in place.

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 nor 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.

(iii) Sliding doors are frequently used in transport helicopters 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).

335. § 29.785 (through Amendment 29-19) SEATS, SAFETY BELTS, AND HARNESSES.

a. Explanation.

(1) This section requires that seats, belts, harnesses, and adjacent parts of the rotorcraft be substantiated for the structural loads resulting from the inertia forces of § 29.561 as well as normal flight and ground inertia forces on a 170-pound occupant. The inertia forces of § 29.561 are ultimate loads and must be multiplied by a factor of 1.33 in determining the "strength of attachment" of each seat to structure and each belt or harness to structure. The seat, belt, etc., are required to sustain applied loads and to protect the occupant from serious injury. The pilot seats must also sustain the effects of the pilot forces of § 29.397.

(2) In addition, the "occupant must be protected from head injury" by the seat belt and one of the following:

(i) A harness to prevent the head from contacting an injurious object.

* (ii) Elimination of injurious object within striking distance of the head.

(iii) A cushioned rest as specified.

(3) Handholds are required to steady occupants using the aisle in moderately rough air.

(4) Projecting objects which would injure occupants "in normal flight must be padded."

b. Procedures.

(1) Each seat with its belts and harnesses are to be substantiated for the flight, ground, and emergency landing loads of § 29.561 by structural test or stress analysis. Section 29.785(b) states that "each seat must be approved." FAA approval can be gained by Technical Standard Order (TSO) approval or by accomplishing sufficient structural substantiation to gain FAA approval of the seat and its belt(s) as part of the Type Design of the rotorcraft. TSO No. C-39 concerns standards for aircraft seats, including rotorcraft seats. If TSO No. C-39 is used as an approval basis for a specific rotorcraft seat, the seat should be checked to assure it has been substantiated for the vertical (up and down) and side loads imposed by installation in the aircraft. For example, TSO No. C-39 (and NAS 809) specifies an ultimate down load of 4.0g which is in agreement with the 4.0g emergency landing load factor of § 29.561, but it may be less than the design maneuver load factor (which can be as high as 3.5g limit or 5.25g ultimate).

(i) The 1.33 factor is specified for substantiation of attachments of each seat to the structure and each safety belt or harness to the seat or structure for § 29.561 loads, whether analysis or test is used.

(ii) If static testing of seats, belts, and harnesses is used, the body block of NAS 809 may be used. The corners of the NAS 809 body block may be radiused and padded if it is found that the small radii cause premature, unrealistic crippling of thin wall tubing or other structure used in the seat.

(iii) The substantiation of the pilot seats is required to include pilot forces of § 29.397 in conjunction with normal flight and ground loads. For example, the pilot foot force (195 pounds ultimate) must be reacted by the seat.

(2) The following criteria have been found satisfactory for preventing occupant head injuries:

(i) If a harness is used, it should support the shoulders without
* applying hazardous loads to the side or front of the neck. It should be easily donned and a single point release with the seat belt is preferred. If separate release is provided, it must be simple, compatible with the seat belt release, and near the seat belt release. The harness should be tested in conjunction with the seat belt using a "body block" similar to that of NAS 809 if possible. If the harness is tested separately from the belt, it should be tested to 50 percent of the forward crash loads for the entire occupant weight of 170 pounds, unless that percentage distribution is found to be unrealistic by a rational analysis.

(ii) Elimination of injurious objects within striking distance of the head and other vital parts can be accomplished by removal of objects with sharp edges or rigid surfaces from within striking distance of vital parts of the occupant. Dimensions and weights for typical occupants are available in U.S. Army USAAULABS Reports 70-22 (August 1969) and 66-39 (June 1966) and NACA Report TN 2991 (August 1953). Because of the range of occupant head striking distance, a combination of "elimination of injurious objects" and "cushioned rests" may be required for some interior configurations.

(iii) An acceptable cushioned rest can be provided by use of a 1-inch thickness of foamed polyvinyl chloride (PVC), or equivalent energy absorbing material. The density of material should be in the 5 to 10 pounds per cubic foot density range. PVC foam has the property of <u>absorbing energy</u> efficiently with negligible rebond effects. PVC foam recovers slowly to the original configuration after deformation. If PVC foam is used, however, care must be taken in its application relative to its flammability characteristics (ref. § 29.853).

(3) Handholds for the occupants are generally provided by seat backs adjacent to the aisle. If the seat backs fold, the amount of support provided by the seat backs before they fold must be evaluated in a furnished interior or mock up. To provide adequate support, the seat back may use an easily disengaged latch or adequate friction in the hinge mechanism to obtain adequate support. Handholds along the aisle are, of course, not needed for rotorcraft with no aisles or where seat belts must be fastened during flight.

(4) Projecting objects which could injure occupants in normal flight should be padded. The amount of padding required depends on the location, size, and minimum radius of the projecting object. In general, this requirement will mean that sharp edges must be padded with one-half inch of PVC foam or equivalent (5 to 10 lbs. density), while objects with radii in excess of 1 inch may meet the requirements of § 29.785(e) with a lesser amount of energy absorbing padding, if it can be contacted only by persons "moving about in the rotorcraft in normal flight." *

* 336. § 29.787 (through Amendment 29-19) CARGO AND BAGGAGE COMPARTMENTS.

a. Explanation.

(1) This section requires that cargo and baggage compartments be designed for normal flight and ground loads and for a 4g ultimate forward load condition. Maximum placarded weights and critical distributions are to be considered.

(2) Means to prevent cargo shifting and contact between any cargo lamp bulb and cargo is to be provided.

b. Procedures. Structure tests or analyses may be used for substantiation for the design loads.

(1) Nets or straps may be used to prevent cargo shifting. The nets or straps are required to be substantiated for the structural loads. They need a means for adjustment to assure proper restraint for different sizes and shapes of cargo.

(2) Cargo lamp bulbs need to be guarded, recessed, or placed in upper inside corners to prevent contact with cargo.

337. § 29.801 DITCHING. (RESERVED).

* 338. § 29.803 (through Amendment 29-19) EMERGENCY EVACUATION.

a. Explanation. This regulation specifies that "means for rapid evacuation in a crash landing" be provided considering the landing gear extended or retracted, and "considering the possibility of fire." Any external exits, whether normal entrance doors or service doors, can be considered as emergency exits if the requirements of §§ 29.805 through 29.815 are met. "Limited amphibian rotorcraft" emergency exits are required to be designed for probable maximum local water pressure (or shown to have nonhazardous failure characteristics) and to have a specified number of exits above the water level. Limited amphibian rotorcraft are approved under the provisions of §§ 29.519 and 29.755(b). Sections 29.801 and 29.807(d) refer to similar standards that pertain to "rotorcraft ditching configurations."

b. Procedures. Exits, arrangement, markings, access, and aisle widths as specified in § 29.805 through 29.815 are to be provided. Recent rotorcraft designs have been approved under the "ditching" standards of § 29.801. Previous "limited amphibian rotorcraft" were designed to the same standards.

339. § 29.805 (through Amendment 29-19) FLIGHTCREW EMERGENCY EXITS.

a. Explanation. Flightcrew emergency exits are required when passenger exits are not convenient. The placement of litters, cargo, or bulkheads may prevent passenger exits from being convenient to the flightcrew. Flightcrew exits, if required, are to be of sufficient size and located on both sides of the rotorcraft (or one top hatch) to "allow rapid evacuation of the flightcrew." A test or tests are required.

b. Procedures. Flightcrew emergency exits, if required, may consist of one overhead hatch or two side exits (one on either side). The size is not explicitly defined except that it be "of sufficient size . . . to allow rapid evacuation of the flightcrew." The ability for "rapid evacuation" should be demonstrated by test. For side exits located immediately adjacent to the crew seat and exceeding Type IV exits (§ 29.807) in size, the test demonstration can be accomplished by normal use and evaluation of the exits by the FAA crew during Type Inspection Authorization (TIA) testing. For any overhead exit or side of fuselage exits not meeting Type IV dimensions, a special demonstration test should be accomplished. This demonstration should show that 2.5 percentile to 97.5 percentile men could egress rapidly through the crew exit(s), i.e., men 5 feet 5 inches to 6 feet 2 inches in height and up to 210 pounds in weight.

* 340. § 29.807 (through Amendment 29-19) PASSENGER EMERGENCY EXITS.

a. Explanation. The normal passenger exits (type and number in each side of fuselage) are specified as follows:

(1) For overland operations.

Passenger Seating Capacity	Emergency exits (rectangular with corner radii of width/3) for each side of the fuselage			
	Floor level			Step-up -29" Max.
	Type I 24" X 48"	Type II 20" X 44"	Type III 20" X 36"	Type IV 19" X 26"
1 through 10				1
11 through 19			1 or	2
20 through 39		1		1
40 through 59	1			1
60 through 79	1		1 or	2

(2) For overwater operations (related to ditching an optional standard).

Passenger Seating Capacity	Emergency exits (rectangular with corner radii of width/3) for each side of the fuselage	
	Threshold Above Waterline	
	Type III 20" X 36"	Type IV 19" X 26" w/step-up - 29"
1 through 9		1
10 through 35	1*	
Each Additional Unit of 35	1*	

* The passenger seat-to-exit ratio may be increased by using larger exits if proven by analyses or tests.

(3) For crash rollover conditions. Sufficient top, bottom, or ends of fuselage exits are to be provided for evacuation unless the probability of the rotorcraft coming to rest on its side in a crash landing is extremely remote.

(4) Ramp exits to replace Type I or II exits are permitted.

(5) Each emergency exit must be functionally tested.

b. Procedures.

(1) The number and size of overland and overwater operation exits will be as specified. The use of oversize exits is allowed if the threshold is flat and of the specified width. *

* (2) The top, bottom, or end fuselage exits should be provided unless features of design are provided which prevent the rotorcraft from coming to rest on its side in a crash landing, and unless sufficient fail-safe and fatigue tests and analyses are conducted of the landing gear and support structure to show it is unlikely that the rotorcraft will come to rest on its side as a result of a single structural failure. An analysis is generally necessary to prove compliance with § 29.807(c).

(3) Ramp exits may be used in place of one Type I or one Type II exit if the required Type I or Type II exit is impractical, and if the § 29.813 exit access requirements are met by the ramp exits.

(4) Each emergency exit is to be opened from the inside and the outside as a functional test. Interior panels and seats should be installed for the exit functional tests to check for interferences and other effects. Section 29.813 pertains to access to the exits.

341. <u>§ 29.809 (through Amendment 29-19) EMERGENCY EXIT ARRANGEMENT</u>.

a. <u>Explanation</u>. Emergency exits are to be provided which result in an unobstructed opening to the outside. The following emergency exit requirements are the same as passenger door requirements of § 29.783 and noted for convenience.

(1) Openable from inside or outside.

(2) Simple and obvious means for opening.

(3) Means for locking.

(4) Means to prevent opening in flight inadvertently or as a result of mechanical failure.

(5) Means to minimize jamming in a minor crash landing.

NOTE: In addition the following emergency exit requirements are: (1) the means of opening may not require exceptional effort; and (2) a slide (for floor level exits) or rope must be provided as prescribed for exits whose thresholds are more than 6 feet from the ground (unless located over the wing). Sections 29.1411(c) and 29.1561 contain other standards for the descent devices.

b. <u>Procedures</u>. Subparagraphs 1 through 5 of the above explanation are covered in the procedure for § 29.783, paragraph 334 of this document. *

* (1) The effort required to open the exit can be evaluated when the tests of § 29.807(f) are conducted. If the effort required to open the exit is in the range of 40 to 50 pounds, it is recommended that a person of slight stature, such as a female in the 90 to 110 pound weight range, be used for the exit opening demonstration/test. In any case, the average load required to operate the exit release mechanism and open the exit should not exceed 50 pounds, and the maximum individual load of a test series should not exceed 55 pounds.

(2) If an approved escape slide, or its equivalent, is provided for exits more than 6 feet from the ground with the landing gear extended, it should be located near the door and conspicuously marked. Automatic inflation and deployment under emergency conditions are the preferred means of operation but are not required by § 29.809. If automatic inflation and deployment features are provided, design features should prevent inadvertent deployment if the exit is a door used for normal entry and/or service. If manual deployment methods are used, they must be simple and easily carried out by a person of slight built and strength. The slide should rapidly inflate upon deployment. See § 29.809(f) for standards concerning an escape rope.

342. § 29.811 (through Amendment 29-19) EMERGENCY EXIT MARKING.

a. Explanation. This regulation covers both the marking and illumination by emergency lighting.

(1) Locating and marking signs are specified for each emergency exit with the following features:

(i) Locating signs and marking signs are to--

(A) Be recognizable from a distance equal to the width of the cabin;

(B) Have 1-inch white letters on a 2-inch red background (colors may be reversed); and

(C) Be self- or electrically illuminated to a minimum brightness of 160 microlamberts.

(ii) Locating signs visible to occupants approaching along the main aisle are required for each exit.

(A) The sign is required next to or above the aisle for floor level exits.

(B) Bulkheads or dividers obscuring exits must have exit locating signs except as stated.

(2) Exit operating or release handle instructions are to be-- *

* (i) Readable from a distance of 30 inches; and

(ii) Supplemented with a red arrow and sign (for Type I or Type II exits with a handle having rotary motion) with the following features provided:

(A) A red arrow with three-fourths inch shaft, a head of twice the shaft width, and 70° arc at 75 percent of handle length.

(B) The word "open" in red letters 1 inch high near the head of the arrow.

(3) Independent source of light, as prescribed, is to be installed to--

(i) Illuminate marking and locating signs;

(ii) Provide general lighting of 0.05 foot-candles at 40-inch intervals at armrest height along the main aisle; and

(iii) Operate manually and automatically in a crash landing and when the normal electrical power is interrupted.

(4) External exit markings are required which include a 2 inch wide band around the exit, identification, and instructions for opening. The external markings are to have a reflectance difference of 30 percent from the fuselage surface finish.

(5) Emergency exits signs may read simply "EXIT."

(6) Excess exits should meet all of the "EXIT" standards or should not be identified as an exit.

b. Procedures.

(1) Emergency exit locating signs may be located to the side of the aisle for small fuselage heights, rather than over the aisle where it may present a hazard to the occupant's head and possibly impede egress. For small passenger cabins one self-illuminated sign stating "EXIT" may be used as both the locating and marking sign for an individual exit on one side of the cabin (operating instructions will, of course, still be required). If one "EXIT" sign is used to both locate and mark the exit, it should be attached to the fuselage above the exit and not to the exit itself. If it is attached to the exit itself and the exit is discarded from the cabin after opening, the locating function of the exit sign is lost when the exit is removed. That is, there is no sign to locate the exit for passengers other than for the one who discarded the exit. The exit locating sign is a necessity to direct all occupants.

(2) Operating instructions should be provided as specified. They should be kept short but clear; e.g., "rotate handle," "push," "pull," etc. *

* (3) Lighting should be provided as specified to illuminate the cabin for egress paths and to supplement lighting of the exit operating instructions signs.

(4) The reflectance of external exit markings can be checked by appropriate electro-optical instrumentation or by use of photometer card sets. Advisory Circular No. 20-47 provides information for complying with identical standards contained in § 25.811. These are also acceptable for § 29.811. The Munsell Color Company, 2441 North Calvert Street, Baltimore, Maryland 21218, provides a set of cards which includes shades of most commonly used colors.

343. <u>§ 29.813 (through Amendment 29-19) EMERGENCY EXIT ACCESS</u>.

a. <u>Explanation</u>. Paragraph (a) of § 29.813 prescribes design details for passageways, both between passenger compartments and for access to Type I and II emergency exits, should they be provided. Such passageways are not made mandatory by § 29.813 although most larger rotorcraft have used them. Some utility or "wide-body" rotorcraft may have open areas between the crew area (pilots) and passenger area (cabin). These configurations may have lateral seating arrangements providing access to emergency exits of Type I or II size, even though they may not be required by § 29.807(b). These designs may not have a main aisle.

(1) Paragraph (c) of this standard concerns access to Type III and Type IV exits. Although "passageways" with explicit requirements are not required for Type III and Type IV exits, "<u>access</u> from each aisle to each Type III and Type IV exit" is required.

(2) For exits whose thresholds are more than 6 feet above the ground, additional space adjacent to the exit is required to allow room for a crewmember to assist passengers with the descent device such as an escape slide or rope noted in § 29.809(f).

(3) In addition to requiring passageways and crewmember space adjacent to exits over 6 feet above the ground, this standard does not allow obstructions in the projected opening of Type III or Type IV emergency exits for one seat width from the exit, except as noted. For passenger seating configurations of 19 or less, minor obstructions into the projection of the exit are allowed only if "compensating factors to maintain the effectiveness of the exit" are provided.

b. <u>Procedures</u>.

(1) The provision for unobstructed passageways, at least 20 inches wide as specified, is straightforward for medium or large cabins with a main aisle and a typical rectangular floor plan. Care should be taken to assure that seats (with lateral or fore-and-aft movement) or galleys (with doors or drawers) are not installed so that they can encroach upon the required passageway. Design features such as stops in seat tracks, seat back mechanisms, stops in galley door (or drawer) mechanisms may be required to assure that unobstructed passageways are provided. *

(2) The requirement (added by Amendment 29-12) that "access from each aisle to each Type III and Type IV exit" be provided may add design features to the interior of many typical compact interiors of medium-size rotorcraft. Rotorcraft with emergency exits located in either hinged or sliding doors and having passenger area encroachment or protusions by compartments for fuel cells, gear boxes, etc., may require special design features to assure that passengers seated to one side or one area of the cabin have "access" to all Type III or Type IV exits on the same or other side of the rotorcraft. The cabin must not be separated into compartments or partitioned. For example, fold down seat back mechanisms may be required for compact cabin configurations having only lateral aisles rather than longitudinal aisles and having Type III or Type IV exits located on each side of the cabin at the end of the lateral seat row or rows.

(3) The space adjacent to an exit that requires a crewmember to assist passengers with descent devices must be large enough to prevent the crewmember from becoming an obstruction in access to the exit. Twenty inches of access must be maintained.

(4) Minor obstructions are allowed in the projected opening of Type III or Type IV exits (for 19 or less passenger seat configurations) if "compensating factors to maintain the effectiveness of the exit" are provided. Compensating factors may include such design features as larger than required exit opening, additional exits beyond the minimum number required, or steps or other assist features which facilitate egress through the exit with the obstruction. Test or analysis may be required to prove the effectiveness of the compensating feature.

344. § 29.815 (through Amendment 29-19) MAIN AISLE WIDTH.

a. Explanation. Main aisle widths are specified in the following table:

Passenger seating capacity	Minimum main passenger aisle width: Less than 25 inches from floor	Minimum main passenger aisle width: 25 inches and more from floor
	Inches	Inches
10 or less----------------	12*	15
11 through 19-------------	12	20
20 or more----------------	15	20

*A narrow width not less than 9 inches may be approved when substantiated by tests found necessary by the Administrator.

* b. Procedures.

(1) Provide the specified aisle minimum width where a longitudinal main aisle is provided in the type design.

(2) Historically, certain rotorcraft with short, wide cabins were initially designed without a longitudinal main aisle for military and cargo use, but were later fitted and approved for civil passenger configuration. These craft generally have 19 or less passenger seats and have either (1) outboard facing passenger seats, (2) a limited number of lateral rows with fold down seats/seat backs, or (3) a combination of lateral and longitudinal rows with and without main aisles to facilitate entrance and egress. *

345. § 29.831 VENTILATION. (RESERVED)

346. § 29.833 HEATERS. (RESERVED)

347.-356. RESERVED.

SECTION 21. FIRE PROTECTION

357. § 29.851 FIRE EXTINGUISHERS. (RESERVED)

SECTION 27. FUEL SYSTEM COMPONENTS

483. § 29.991 (through Amendment 29-19) FUEL PUMPS.

a. Explanation.

(1) Section 29.991, paragraph (a), provides a definition of the main pump(s) and § 29.991, paragraph (b), requires an "emergency pump(s)." The main pump(s) that is certified as part of the engine does not fall under § 29.991 requirements. The main pump(s) discussed under § 29.991 should therefore be considered "main aircraft pump(s)."

(2) The main aircraft pump(s) consists of whatever pump(s) is required to meet engine or fuel system operation throughout the range of ambient temperature, fuel temperature, fuel pressure, altitude, and fuel types intended for the rotorcraft. If the main aircraft pump(s) is required to meet the above criteria, then an emergency pump(s) is required.

b. Procedures.

(1) Each pump classified as a main aircraft pump, which is also a positive displacement pump, must have provisions for a fuel bypass. An exception is made for fuel injection pumps used on certain reciprocating engines and for the positive displacement, high pressure, fuel pumps routinely used in turbine engines. The bypass may be accomplished via internal spring check valve and fuel passage, or by external plumbing and a check valve. High capacity positive displacement pumps with internal pressure relief and recirculation passages should be checked for overheating if they may be expected to operate continuously at or near 100 percent recirculation.

(2) Section 29.991, paragraph (b) specifies a requirement for "emergency" pumps to provide the necessary fuel after failure of any (one) main aircraft pump. (Injection pumps and high pressure pumps used on turbine engines are exempt.) As stated in this rule, the "emergency" pump must be operated continuously or started automatically to assure continued normal operation of the engine. For some multiengine rotorcraft, another main aircraft pump may possibly be used as the required "emergency" pump. In this case, the dual role of this pump requires it to have capacity to feed two engines at the critical pressure/flow condition. Availability of fuel flow from this backup pump must be automatic and this function should be verified in the preflight check procedure. For Category A rotorcraft, a comprehensive fault analysis of the fuel system is mandatory to assure compliance with § 29.903, paragraph (b).

(3) Section 29.991, paragraphs (c)(1)(i) and (ii) address the situation, usually associated with supercharged reciprocating engines, where fuel pressure must be modulated with respect to carburetor deck pressure. This is accomplished with interconnecting air lines from the carburetor intake (after the supercharger) to the pressure relief connection on the fuel pump(s). A similar connection from the carburetor intake to the vented side of the fuel pressure gauge is needed to obtain correct fuel pressure reading. These systems may require orifices and/or surge chambers to operate correctly.

(4) Section 29.991, paragraphs (c)(2) and (3) requires seal drains which drain safely. A drain impingement test is normally required to verify safe drainage. Use of a colored dye to simulate fuel discharge at the drain line exit or a fluid sensitive coating (Bon Ami) on the aircraft skins will facilitate evaluation of the safety aspects of drain impingement. Pump seal drain requirements would not be applicable for tank immersed pumps.

484. § 29.993 (through Amendment 29-19) FUEL SYSTEM LINES AND FITTINGS.

a. Explanation. This rule outlines design requirements for fuel system lines.

b. Procedures.

(1) Compliance is usually obtained by employing routing and clamping as described in paragraph 709, Chapter 14, Section 2 of AC 43.13-1A and by monitoring the arrangement throughout the developmental and certification test period. Requirements for approved flexible lines may be resolved by utilizing lines listed as TSO C53a approved for installation in either normal or high temperature areas as appropriate.

(2) Verify adequate clearance exists between lines and elements of the rotorcraft control system at extremes of control travel, including control deflections and, for flexible lines (hoses), possible variations in routing.

(3) Flexible lines inside fuel or oil tanks require special evaluation to assure that the external surfaces of these lines are compatible with the fluids involved and that fluid sloshing will not cause line failure. Lines inside tanks should be routed to avoid impingement by fuel or oil filler nozzles.

(4) Good design practice suggests that all flammable fluid lines should be routed to minimize the possibility of rupture in the event of a crash or from engine rotor disc failure.

485. § 29.995 (through Amendment 29-19) FUEL VALVES.

a. Explanation. This regulation requires that fuel valves be supported so that no loads resulting from their operation or from accelerated flight conditions are transmitted to the lines attached to the valve.

b. Procedures. Compliance with this rule is usually accomplished by designing the installation of the fuel valve so that the valve is supported by either primary or secondary airframe structure.

486. § 29.997 (through Amendment 29-19) FUEL STRAINER OR FILTER.

a. Explanation. This rule provides for a main in-line fuel filter designed to collect all fuel impurities which could adversely affect fuel system and engine components downstream of the filter. The rule also requires a sediment bowl and drain (or that the bowl be removable for drain purposes) to facilitate separation of contaminations, both solid and liquid, from the fuel.

b. Procedures.

(1) The filter should be mounted in a horizontal segment of the fuel line to facilitate proper action of the sediment bowl. If the filter is located above the fuel tank, it becomes necessary to activitate a fuel boost pump to achieve positive drainage of the filter bowl. Without pump pressure, air may enter the fuel system during the filter draining operation and, for turbine engines, result in transient power surges or engine failure during subsequent engine operation. A flight manual note to require pump(s) to be "on" during filter draining would be appropriate.

(2) Section 29.997(d) sets forth a requirement for filter capacity and for filter mesh. The capacity requirement may be substantiated by showing that the filter, when partially blocked by fuel contaminates (to a degree corresponding to the indicator marking or setting required by §29.1305(a)(17)), does not impair the ability of the fuel system to deliver fuel at pressure and flow values established as minimum limitations for the engine. The filter mesh must be sized to prevent passage of particulate which cannot be tolerated by the engine. FAR Part 33 requires that the degree and type of filtration be established. This information should be the base for selecting the filter mesh. Although a test may be devised and conducted, data from the filter manufacturer usually are acceptable to verify compliance. Note that when the filter capacity is reached, continued flow of contaminated fuel may result in engine failure. A flight manual note regarding precautionary procedures is appropriate.

(3) FAR Part 33 (through Amendment 33-6) has an identical requirement for a fuel filter for engine fuel systems; however, it is not intended that two filters should be required.

* 487. § 29.999 (through Amendment 29-19) FUEL SYSTEM DRAINS.

a. Explanation. This regulation provides for fuel system drains and defines the requirements which the system must meet.

b. Procedures.

(1) The location and function of the fuel system drains are an integral part of any fuel system. There may be several drains required dependent upon the fuel system design. Each fuel tank sump and certain types of fuel strainers or filters require a means to drain (ref. §§ 29.971 and 29.997).

(2) Selection of the location and orientation of the drain discharge in the design phase is important to assure that there is no impingement on any part of the rotorcraft. To show compliance with the requirement may require tests dependent upon whether the applicant has a previously approved design which is similiar, or if the system is a new design for which no previous experience is available.

(3) The location of the drain valve should be selected so that the requirements for accessibility, ease of operation, and protection are met.

(4) Advisory Circular 20-119 provides an acceptable means, but not the only means, of compliance with the requirement for positive locking of fuel drain valves in the closed position.

(5) The fuel drain installation on aircraft with retractable landing gear will be satisfactory if recessed within the outside surface of the aircraft.*

488.-497. RESERVED.

* 501. <u>§ 29.1017 (through Amendment 29-19) OIL LINES AND FITTINGS</u>.

a. <u>Explanation</u>. This regulation outlines the certification requirements for oil lines and fittings.

b. <u>Procedures</u>. The oil system lines and fittings are required to meet the requirements of § 29.993; therefore, the routing and clamping described in Par 709, Chapter 14, Section 2, of AC 43.13-1A may be utilized as guidance for the system design. An evaluation carried out through the development and certification test period will usually surface any problems of interference and/or vibration.

(1) When flexible hoses are used in the lubrication system they must be substantiated. Hoses listed in TSO C53a may be used which would preclude certain substantiation requirements.

(2) Location of the breather lines and discharge should be carefully evaluated to determine that the requirements of this paragraph are followed.

(3) The routing of fluid lines should be such that drooping lines and fluid traps which are undrainable are avoided.

502. <u>§ 29.1019 (through Amendment 29-19) OIL STRAINER OR FILTER</u>.

a. <u>Explanation</u>. This regulation defines the requirements for the engine oil system strainer or filter. If a strainer or filter which meets the requirements of this paragraph is incorporated as part of the type certificated engine, an additional airframe filter is not required.

b. <u>Procedures</u>. This paragraph requires an oil strainer or filter through which all of the oil flows for each turbine engine installation. The strainer or filter should be sized to allow oil flow at the flow rates and within the pressure limits as specified in the engine requirements. The effect of oil at the minimum temperature for which certification is sought should be accounted for.

(1) For each oil strainer or filter required by § 29.1019(a) which has a bypass, the bypass should be sized to allow oil flow at the normal rate through the oil system with the filtration means completely blocked.

(2) For each oil strainer or filter installed per this rule, the capacity must be such that the oil flow and pressure are within the operating limits established for the engine. The mesh requirements are determined by the engine specification for the filtration of particle size and density. *

(3) Section 29.1019(a)(3) requires an indicator that will show when the contaminant level of the filtration system, as specified in § 29.1019(a)(2), has been reached. The indicator should signal a contaminant level which has not caused the filter to go into a bypass condition. Consideration should also be given so that the contaminant level at which the indicator is activated is such that the filter would not bypass during a flight time based on full fuel at a cruise condition with the lubricant contaminated to the degree used to show compliance with § 29.1019(a)(2).

(4) An evaluation of the construction and location of the bypass associated with the strainer or filter should be accomplished. The appropriate installation of the filter based on this evaluation would preclude the release of the collected contaminants in the bypass oil flow.

(5) If an oil strainer or filter installed in compliance with this regulation does not have a bypass, there must be a means to connect it to the warning system required in § 29.1305(a)(18). This warning should indicate to the pilot the contamination before it reaches the capacity established in § 29.1019(a)(2). Section 29.1019(b) covers the blocked oil filter requirements associated with reciprocating engine installations. The lubrication system should be such that the normal oil flow will occur with the filter completely blocked.

503. § 29.1021 (through Amendment 29-19) OIL SYSTEM DRAINS.

a. Explanation. This regulation requires provisions be provided for safe drainage of the entire oil systems and defines certain requirements for assuring that no inadvertent oil flow occurs from the system provided.

b. Procedures. The design of the oil system must provide a means for safe drainage of the entire oil system. This may require one or more drains dependent upon the design of the system. If a valve is used for this function, it must provide a means for a positive lock in the closed position. The method by which the lock is accomplished may be manual or automatic.

504. § 29.1023 (through Amendment 29-19) OIL RADIATORS.

a. Explanation. This regulation defines the installation requirements to be considered for oil system radiators.

b. Procedures.

(1) The primary concern with respect to oil radiators is that they are sized to provide the required heat rejection and to provide adequate fluid flow within the prescribed pressure limits. •

* 499. § 29.1013 (through Amendment 29-19) OIL TANKS.

a. Explanation This regulation identifies the requirements that each oil tank must meet. It also specifies that the oil tank installation must meet the installation requirements of § 29.967.

b. Procedures.

(1) The oil tanks usually are constructed of aluminum, aluminum alloy, or stainless steel and are of such a design to permit installation in the aircraft as close to the engine as the design allows. The choice of materials will generally be determined by the selected location of the tank. The tank envelope or outline will generally be determined by the location within the structure of the helicopter.

(2) The design of the tank is required to meet the expansion space requirements as specified in the regulation for the particular installation. This is generally accomplished by locating the filler cap in such a manner that the expansion space cannot be inadvertently filled with the rotorcraft in normal ground attitude.

(3) The tank is required to be properly vented and the vent requirements are identified in the regulation.

(4) Unless alternate means are provided, it is good design practice to locate the oil tank with respect to the engine so that when the helicopter is in its normal ground attitude, a positive head to the oil pump inlet is provided.

(5) Sections of the regulation address specific requirements when Category A certification is requested.

(6) The designer should be aware of the requirements associated with the location of the oil tank outlet and the marking requirements specified in § 29.1557(c)(2).

(7) Flexible oil tank liners may be used; however, they must be approved or shown to be suitable for the particular installation.

(8) An "external oil system" which is defined as being those components, lines, etc., of an oil system which are outside the engine and not supplied as part of a certificated engine. The components of such a system which are within the fire zone and required to be fire resistant. Those outside the fire zone need not be fire resistant. *

500. § 29.1015 OIL TANK TESTS. (RESERVED)

SECTION 28. OIL SYSTEM

* 498. § 29.1011 (through Amendment 29-19) GENERAL.

a. Explanation.

(1) This regulation defines the oil system requirements for engines and the rotor drive systems which require continuous lubrication.

(2) Each engine must have an independent oil system. This lubrication system performs two functions. It provides an adequate oil supply and it incorporates a means of cooling the hot oil discharged from the engine. Acceptable oil quantities must be determined and the system designed to accommodate this quantity.

(3) The adequacy of the oil systems to maintain the oil temperature at or below the specified limits must be shown under the applicable requirements of §§ 29.1041 through 29.1049.

b. Procedures.

(1) To provide engine isolation, meeting the regulations requires completely independent lubrication systems in multiengine rotorcraft. This includes separate oil tanks, oil coolers, oil cooler blowers, and the associated plumbing. Alternate designs providing an equivalent level of independence may be used if substantiated. A single failure of any one system may not--

(i) Prevent continued safe operations of the remaining engine(s); or

(ii) Require immediate action by any crewmember for continued safe operations.

(2) Any rotor drive system which requires continuous lubrication must be sufficiently independent to ensure operation with any engine inoperative. The oil cooling provisions of this system should be sufficient to provide adequate cooling at maximum continuous power of the drive system and critical conditions associated with any single engine failure. The system must also provide for a safe autorotation.

(3) The usable oil quantity for the oil systems may be determined in several ways and the required quantities will vary between piston engine installation and turbine engine installation. Several methods of determining the usable oil capacity are provided in the regulations. However, when oil-fuel ratios other than those prescribed are used, they must be substantiated by data on the oil comsumption of the engine. *

* (3) In showing compliance with the cooling requirements, the applicant should not be required to exceed rotorcraft established limits (gross weight, drive system torque, measured gas temperature, etc.), aircraft power required, or power available. The applicant may elect, however, to exceed these limits in order to minimize test points by conservative testing, or to anticipate future growth (increased gross weight etc.).

(4) The need for a comprehensive cooling test plan prior to certification testing cannot be overemphasized. Highly derated engine installations, the relationship of power required to power available, the use of bleed air devices which would increase the measured gas temperature while aircraft power required remains the same, auxiliary cooling provisions, and the increase in engine temperatures with engine deterioration are factors which could affect the selection of cooling demonstration test points. The following paragraphs will provide some general guidance, but the cooling test plan is the key to a successful program.

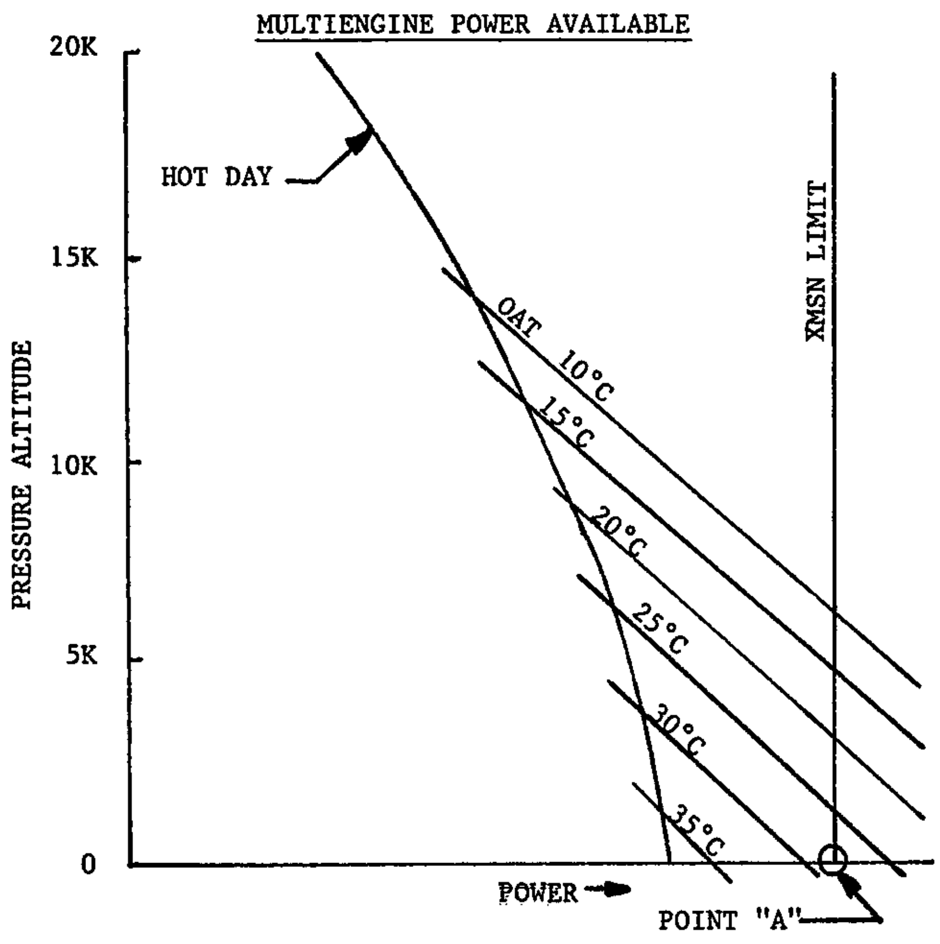

FIGURE 516-1 ADDITIONAL COOLING TEST POINT

(3) The component and fluid temperature correction factor to be applied when test ambients do not correspond to the hot day conditions is commonly called the "degree-for-degree correction." It may be possible to justify, and the regulation allows the application of a more rational, less conservative correction factor. A correction factor other than degree-for-degree should be based on engineering test data.

(4) No corrected temperatures may exceed established limits. In order to maintain temperatures within established limits, the applicant may be willing to accept lesser performance than the full capability of a device. For example, a starter/generator capable of cooling under test cell conditions to 200 amperes continuous load may be limited to a lesser value, perhaps to 150 amperes, when installed in the aircraft due to cooling considerations. This continuous load for cooling must be equal to or greater than the allowable continuous load designated on aircraft instruments.

c. Thermal Limit Correction.

(1) An important correction factor which is not discussed in the regulations, but is frequently necessary to show the cooling adequacy required by § 29.1041, is the thermal limit correction factor. This factor is sometimes required if, at test day conditions, the engine measured gas temperature does not correspond to that which would have occurred on a minimum specification engine at hot day conditions.

(2) The correction factor would not apply to those components not affected by changes in measured gas temperature (MGT) at a constant power. Typical items expected to be affected by changes in the MGT at constant power would be engine oil temperature, thermocouple harnesses, or other fluid, component, or ambient temperatures in the vicinity of the engine hot-section or exhaust gases. Other items remote from the hot-section, perhaps the starter-generator or fuel control, would not be expected to be influenced by MGT variations; however, the items affected and the magnitude of the factor to be applied should be established by testing.

(3) There are several acceptable methods for establishing the appropriate thermal limit correction factor during development testing. The general idea is to establish a stabilized flight condition, typically ground-run or IGE hover, and to vary the measured gas temperature at approximately fixed power and OAT conditions. This may be accomplished by utilizing engine anti-ice bleed air, customer bleed air, or by ingesting warmer than ambient air (either an external source or the engine bleed air) into the engine inlet. Care should be used in ingesting warmer than ambient air to assure that the warm air is diffused in order to avoid possible engine surge. *

(i) If it is not possible to attain a suitable variation in MGT by these methods, an acceptable, but more conservative thermal limit correction may be obtained by allowing both shaft horsepower and MGT to vary at a stabilized flight condition and OAT.

(ii) The component temperature is plotted as a function of MGT, and the thermal limit correction from any test day MGT for any flight condition, to the MGT that would have existed with minimum specification engines on a hot day, is then applied to derive the final measured component temperature.

(4) In certain rare instances, it may not be required that the correction factor be applied to the full thermal limit capability of the engine. Consider the following example for the hot day hover IGE cooling test point at sea level.

	Power (SHP)	Corresponding MGT (°C)
Drive System Limit	900	---
Twin Engine Hot Day Power Available	1,050	750
Hot Day Power Required at Maximum G.W.	850	650
Engine Maximum Allowable MGT (Instrument Marking)	---	765
Test Day (90° F OAT) Parameters	850	600

(i) Notice that the installed hot day power available MGT from the engine performance program, is 15° C cooler than the limit MGT (750° vs. 765° C), thus the engine has 15° C "field margin" which would allow the engine temperature to gradually increase 15° C to maintain a given power as engine life is utilized. Secondly, the measured gas temperature corresponding to hot day power required at maximum gross weight, is less than that corresponding to either the drive system limit or twin engine hot day power available. Thus, the thermal limit correction could be applied from the test day MGT, 600° C, to the power required MGT plus the field margin, 650° C plus 15° C, rather than applying the correction factor to the full thermal capability of the engine, 765° C.

(ii) Care should be used in applying this relieving method, because as the hover altitude changes, the maximum gross weight and power required (and the associated MGT) will vary. The data must be corrected to at least the maximum MGT for a minimum specification engine that can occur in service at the flight condition under investigation.

518. § 29.1045 (through Amendment 29-19) CLIMB COOLING TEST PROCEDURES.

a. Objective. The objective of the regulation is to verify, for Category A and for Category B rotorcraft described, that cooling provisions are adequate for a one-engine-inoperative (OEI) climb or descent initiated from a multiengine cruise at the critical altitude with stabilized component temperatures. The specific flight conditions and powers are described in the regulation.

b. Explanation.

(1) This regulation specifies climb or descent cooling with OEI for Category A rotorcraft and for Category B rotorcraft with Category A powerplant isolation and fireproof or isolated structure, controls, etc., which are essential for controlled flight and landing. For the Category B machine described, the testing should be accomplished at the steady rate of climb or descent established under § 29.67(b), i.e., at the best OEI rate of climb (or descent) and the remaining engine at maximum continuous power or 30-minute power, whichever is applicable.

(2) The engine whose shutdown has the most adverse effect on the cooling conditions for the remaining engine(s) and powerplant components should be inoperative.

(3) The regulation provides that the climb cooling test may be conducted in conjunction with the takeoff cooling test of § 29.1047. This possible combining of tests applies only to § 29.1047(a), since § 29.1047(b) is a multiengine climb and not related to the OEI climb procedures of § 29.1045.

c. Procedures.

(1) The OEI climb cooling test point begins from a multiengine cruise, with stabilized fluid and component temperatures, 1,000 feet below either the all-engine-critical altitude or the maximum altitude at which the rate of climb is 150 f.p.m., whichever is the lowest altitude. If the minimum altitude derived is less than sea level, the climb should begin from a twin engine cruise with stabilized fluid and component temperatures at the minimum practical altitude.

(i) The all-engine-critical altitude is the maximum altitude at which, for the ambient conditions prescribed, it is possible to maintain the multiengine specified power. For example, if for multiengine operations, the transmission maximum continuous torque can be maintained on the hot day to a maximum altitude of 10,000 feet above which power would have to be reduced because of gas temperature or other limitations, then 10,000 feet is the all-engine-critical altitude. Point "A" in figure 518-1 illustrates the all-engine-critical altitude.

(ii) The 150 f.p.m. climb criteria should be based on multiengine operation at maximum continuous power available at hot day conditions at maximum gross weight. *

(iii) Fluid and component temperatures are considered stabilized when the rate of change is less than 2° F per minute.

(2) The OEI climb power to be utilized is 30-minute OEI hot day power available (if approval of 30-minute power on the aircraft is requested), followed by maximum continuous hot day power available. If 30-minute OEI power approval is not requested, the power to be utilized would be maximum continuous hot day power available.

(i) Rotorcraft for which approval of a continuous OEI power rating is requested would use the power available on a hot day at the maximum continuous OEI rating following the 30-minute OEI climb phase (or for the entire climb if approval of 30-minute OEI power is not requested).

(ii) If the maximum continuous OEI approval is not requested, then the highest hot day power available approved for continuous usage from the remaining engine(s) under OEI conditions would be used following the 30-minute OEI climb phase (or for the entire climb if approval of 30-minute OEI power is not requested).

(3) In order to achieve representative test results, the helicopter climb rate and airspeed should approximate those which would occur on a hot day. This is accomplished by adjusting helicopter gross weight as required to produce the desired climb rate based on published or predicted climb performance data. The possible adverse effects of climb fuselage attitude on cooling air duct entrances should be considered in the selection of center-of-gravity of the test aircraft.

(4) The OEI climb should be continued for at least 5 minutes after the occurrence of the highest temperature recorded or until the maximum certification altitude is reached. Generally, temperatures would be expected to peak a short time after the climb begins since component and fluid temperatures are stabilized prior to entry to the climb phase.

(5) For Category B rotorcraft, defined in § 29.1045(a)(2) without a positive OEI rate of climb, the descent should begin from a hot day maximum continuous power multiengine cruise, with stabilized fluid and component temperatures, at the all-engine-critical altitude.

(6) The descent should conclude at either the maximum altitude at which level flight can be maintained with one engine inoperative or at the minimum practical altitude, whichever is higher.

(7) The OEI powers available to be utilized during the descent would be the same as those prescribed previously for OEI climb cooling. OEI operation should continue until component and fluid temperatures stabilize. *

SECTION 31. EXHAUST SYSTEM

548. § 29.1121 GENERAL. (RESERVED)

549. § 29.1123 EXHAUST PIPING. (RESERVED)

550. § 29.1125 EXHAUST HEAT EXCHANGERS. (RESERVED)

551.-560. RESERVED.

SECTION 32. POWERPLANT CONTROLS AND ACCESSORIES

561. § 29.1141 POWERPLANT CONTROLS: GENERAL. (RESERVED)

562. § 29.1142 AUXILIARY POWER UNIT CONTROLS. (RESERVED

563. § 29.1143 ENGINE CONTROLS. (RESERVED)

564. § 29.1145 IGNITION SWITCHES. (RESERVED)

565. § 29.1147 MIXTURE CONTROLS. (RESERVED)

566. § 29.1151 ROTOR BRAKE CONTROLS. (RESERVED)

567. § 29.1157 CARBURETOR AIR TEMPERATURE CONTROLS. (RESERVED)

568. § 29.1159 SUPERCHARGER CONTROLS. (RESERVED)

569. § 29.1163 POWERPLANT ACCESSORIES. (RESERVED)

570. § 29.1165 ENGINE IGNITION SYSTEMS. (RESERVED)

571.-583. RESERVED.

SECTION 33. POWERPLANT FIRE PROTECTION

584. § 29.1181 DESIGNATED FIRE ZONES: REGIONS INCLUDED. (RESERVED)

585. § 29.1183 FLAMMABLE FLUID-CARRYING COMPONENTS. (RESERVED)

586. § 29.1185 FLAMMABLE FLUIDS. (RESERVED)

587. § 29.1187 DRAINAGE AND VENTILATION OF FIRE ZONES. (RESERVED)

588. § 29.1189 SHUTOFF MEANS. (RESERVED)

589. § 29.1191 FIREWALLS. (RESERVED)

590. § 29.1193 COWLING AND ENGINE COMPARTMENT COVERING. (RESERVED)

591. § 29.1194 OTHER SURFACES. (RESERVED)

592. § 29.1195 FIRE EXTINGUISHING SYSTEMS. (RESERVED)

593. § 29.1197 FIRE EXTINGUISHING AGENTS. (RESERVED)

594. § 29.1199 EXTINGUISHING AGENT CONTAINERS. (RESERVED)

595. § 29.1201 FIRE EXTINGUISHING SYSTEM MATERIALS. (RESERVED)

596. § 29.1203 FIRE DETECTOR SYSTEMS. (RESERVED)

597.-616. RESERVED.

SECTION 34. EQUIPMENT - GENERAL

617. § 29.1301 FUNCTION AND INSTALLATION. (RESERVED)

618. § 29.1303 FLIGHT AND NAVIGATION INSTRUMENTS. (RESERVED)

619. § 29.1305 POWERPLANT INSTRUMENTS. (RESERVED)

620. § 29.1307 MISCELLANEOUS EQUIPMENT. (RESERVED)

(8) The airspeeds utilized in the climb and descents should be representative of normal speeds unless cooling provisions are sensitive to rotorcraft airspeed, in which case the airspeeds most critical for cooling should be used. In no case, however, should it be required that the selected airspeeds exceed the speeds established under §§ 29.67(a)(2) and 29.67(b).

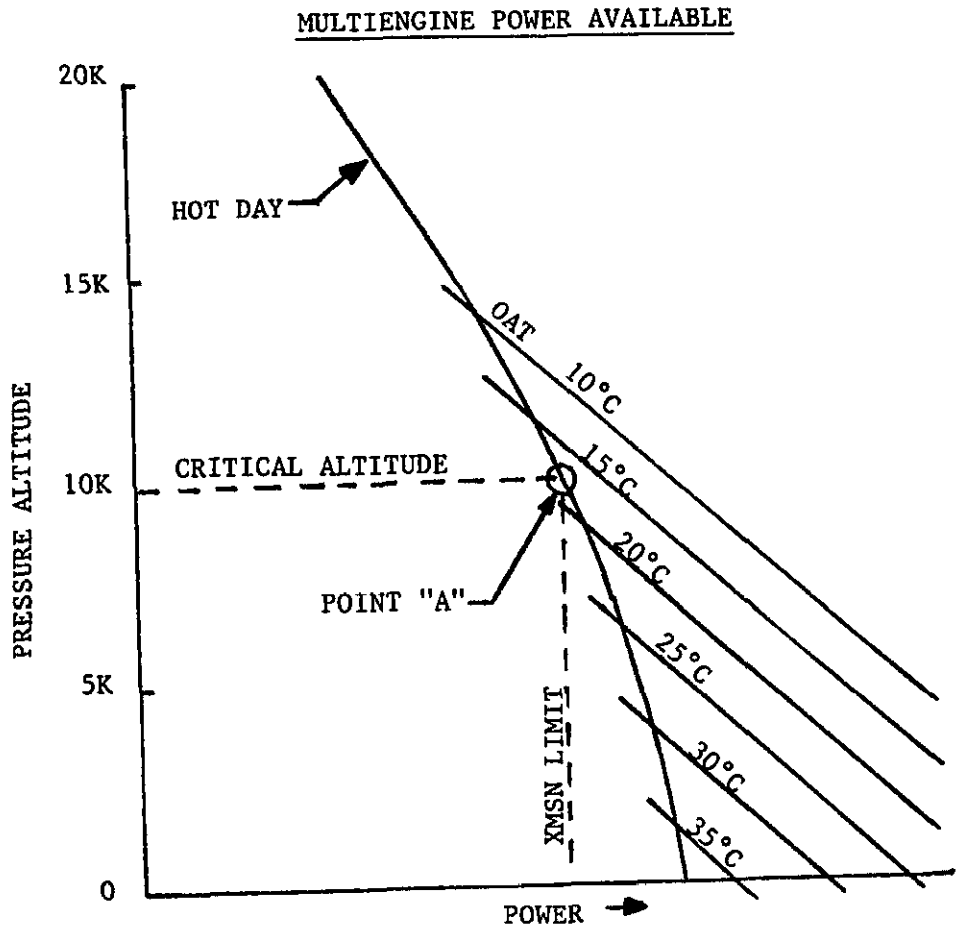

FIGURE 518-1 ALL-ENGINE-CRITICAL ALTITUDE

(3) Green signifies a safe operating condition and more specifically has come to signify landing gear extended and locked. Extensive use of green annunciators throughout the cockpit should generally be avoided due to possible confusion with the special use of green for landing gear. If green annunciators are physically and functionally removed from the landing gear operation, they may be found acceptable for a variety of "safe operating" applications. One such application is "all green for approach," used in autopilot, flight director, and other navigation system displays.

(4) Other colors may be utilized as advisory lights in accordance with § 29.1322(d). Red and amber must not be used as advisory lights due to the possibility of introducing confusion into the cockpit. Obviously, yellow and pink annunciators should be avoided due to their similarity to amber and red. White and blue have been succesfully utilized as advisory segments in past civil designs.

(5) The primary test for designation of color is:

(i) Red - Is immediate action required?

(ii) Amber - Is pilot action (other than immediate) required?

(iii) Green - Is safe operation indicated, and is the indication sufficiently distinct to prevent confusion with the landing gear down indication?

(iv) Other advisory lights - Is the meaning clear and distinct enough to prevent confusion with other annunciations? Do the colors which are utilized differ sufficiently from the colors specified in paragraphs b(1), (2), and (3) above?

(6) Annunciator lights should be visible during bright daylight conditions. This should include visibility in direct sunlight unless lights are located in such a manner that direct sunlight cannot impinge on them.

(7) If dimming capability is provided, all annunciators, including master warning and caution, may be dimmable so long as the annunciation is clearly discernable for night operation at the lower lighting level. Undimmed annunciations have been found unacceptable for night operation due to disruption of cockpit vision at the high intensity. The dimming circuit should automatically revert to the high intensity setting when power is removed. Automatic dimming/brightening through the use of a photo cell is also acceptable, as are circuits which enable a dimming switch through a position light or other cockpit lighting controls.

(8) The use of flashing lights should be minimized. If a flashing feature is used, it should be controllable through pilot action so that flashing annunciation does not persist indefinitely. The indicator should be so designed that if it is energized and the flasher device fails, the light will illuminate and burn steadily.

(9) Refer to paragraph 779 of this Advisory Circular, Annunciator Panels, for additional design information.

634. <u>§ 29.1323 AIRSPEED INDICATING SYSTEM. (RESERVED)</u>

635. <u>§ 29.1325 STATIC PRESSURE AND PRESSURE ALTIMETER SYSTEMS. (RESERVED)</u>

636. <u>§ 29.1327 MAGNETIC DIRECTION INDICATOR. (RESERVED</u>

637. <u>§ 29.1329 AUTOMATIC PILOT SYSTEM. (RESERVED)</u>

638. <u>§ 29.1331 INSTRUMENTS USING A POWER SUPPLY. (RESERVED)</u>

639. <u>§ 29.1333 DUPLICATE INSTRUMENT SYSTEMS. (RESERVED)</u>

* 640. § 29.1335 (through Amendment 29-19) FLIGHT DIRECTOR SYSTEMS.

a. Explanation. This section prescribes the accepted display criteria for a helicopter three-cue flight director providing command guidance for pitch, roll, and power. Three-cue flight directors for helicopters use the usual pitch and roll command cues with the third cue displayed on the left side of the attitude director indicator (ADI). These instruments can be used in either the two-axes or three-axes modes. In either mode, the lateral command cue controls the roll attitude and the vertical command cue controls the pitch attitude. The helicopter attitude, controlled by the cyclic control, is changed to satisfy the flight director commands. The third cue, when displayed, commands collective pitch position and is used when an airspeed or pitch attitude mode and a vertical mode (altitude hold, glide slope, etc.) are selected.

(1) The general convention for flight director design is that each command bar is a "fly to" command. The motion of the flight director indicator is such to command a corresponding sense of control system motion. This is true of flight director pitch and roll commands and should hold true for additional commands such as collective pitch.

(2) Some consideration should be given to the collective or third cue display. For example, if the collective symbol is selected as the fixed index, the command cue and collective pitch control should move in opposite directions when collective pitch changes are made. This configuration would constitute a conventional "fly to" indicator. If the collective symbol is selected for the movable index, the direction of motion of the collective symbol will coincide with the direction of collective pitch changes. In this case the moving collective symbol does not comply with the "fly to" convention; however, this configuration has been approved by the FAA with special symbology, special background effects, and special color coding, and has performed satisfactorily in service.

b. Procedures. The recommended display for a three-cue flight director incorporates the standard pitch and roll command symbols, either pitch and roll bars or the "V" bar display. The third cue, or collective symbol, should be located on the left side of the ADI. The shape of the moving cue and the background display should be unique to avoid being confused with a glide slope display or angle of attack display. One display uses a third cue, shaped like a small handle, to aid in identifying it as the collective pitch symbol.

(1) The color of the pitch and roll command indicators, the aircraft symbol, the background marking of the third cue, and third cue itself, should be consistent. The optimum color scheme uses the same color for the aircraft symbol and the collective symbol. This is usually fire orange. The command cues including the collective cue also should use the same color, usually yellow. The rationale for the different colors is that the aircraft symbol and the collective symbol (the same color) are moved toward their respective command cues. If the pitch command cue is above the center, the aircraft symbol is raised (nose pulled up) and, if the collective command cue is above the collective symbol, the collective pitch is raised, moving the collective symbol towards the command cue. *

* (2) If the attitude director indicator (ADI) provides a monochromatic display, the collective pitch cue and its background markings must be distinctive to reduce the chance of being confused with the glide slope indicator. This can be accomplished through the use of different shaped cues and background marks. A round cue with a chevron-shaped background marking has been satisfactory. *

(ii) Vibrating pencils, name plates, or permanent inks may be used. However, serial numbers should be applied on each part such that material is upset or displaced on the part, thereby attaining a more permanent number. This is not a requirement however. When material is upset or displaced the least critical or lowest stressed area should be used.

(iii) For small parts, the rule (§ 45.14) allows markings that are equivalent to part and serial numbers. Markings or symbols may be used to enable the identification of a part as one for which a replacement time, inspection interval, or related procedure is specified in the Airworthiness Limitations Section. The FAA stated identification of such small parts is clearly essential for safety and may not be relieved. With adoption of Amendment 29-20, the marking requirements are contained in § 45.14, Amendment 45-12.

(3) The FAA inspector should witness the rigging of the controls of a test rotorcraft. This is imperative for a new helicopter design to assure the practicality and feasibility of the procedures stated in the design data and/or the maintenance manual. The type design data information should be used; then the FAA should assure the manual includes the proper information. Rigging procedures are not included in the airworthiness limitations section.

(4) A draft copy of the manual should be available to the FAA for use during the F&R program if such a program is conducted under § 21.35(b). The manual must be completed and furnished with each aircraft receiving an airworthiness certificate.

730.-739. RESERVED.

SECTION 41. MARKINGS AND PLACARDS

740. § 29.1541 GENERAL. (SEE PARAGRAPH 781)

741. § 29.1543 INSTRUMENT MARKINGS: GENERAL. (SEE PARAGRAPH 781)

742. § 29.1545 AIRSPEED INDICATOR. (SEE PARAGRAPH 781)

* 743. § 29.1547 (through Amendment 29-19) MAGNETIC DIRECTION INDICATOR.

a. Explanation. This regulation identifies the requirement for a calibration placard for the magnetic direction indicator and where it should be located.

b. Procedures. One means of accomplishing the requirements of this regulation is commonly known as swinging the compass. A surveyed compass rose is laid out on an appropriate surface. The compass rose location should be free from the influence of steel structures, underground pipes and cables, reinforced concrete, and other aircraft. The aircraft should be in an attitude which permits an accurate result. Normally the engines are in operation; however, if the helicopter is equipped with an auxiliary power unit which can supply all required electrical power, this can be used in lieu of engine driven generators. Turn the aircraft on successive headings through 360°. It is recommended that the increments be every 30°; however, the increments should not exceed 45°. Prepare a placard to show the correction to be applied at each of the selected headings. When significant errors are introduced by operation of electrical/electronics equipment or systems, the placard should also be marked at each calibration heading showing the correction to be applied when such equipment or systems are turned on or energized. The placard resulting from this calibration should be installed on or near the magnetic direction indicator. *

744. § 29.1549 POWERPLANT INSTRUMENTS. (SEE PARAGRAPH 781)

745. § 29.1551 OIL QUANTITY INDICATOR. (RESERVED)

746. § 29.1553 FUEL QUANTITY INDICATOR. (RESERVED)

747. § 29.1555 CONTROL MARKINGS. (RESERVED)

748. § 29.1557 MISCELLANEOUS MARKINGS AND PLACARDS. (RESERVED)

749. § 29.1559 LIMITATIONS PLACARD. (RESERVED)

750. § 29.1561 SAFETY EQUIPMENT. (RESERVED)

751. § 29.1565 TAIL ROTOR. (RESERVED)

752.-761. RESERVED.

SECTION 42. ROTORCRAFT FLIGHT MANUAL

* 762. § 29.1581 (through Amendment 29-19) GENERAL.

a. Explanation.

(1) The primary purpose of the Rotorcraft Flight Manual (RFM) is to provide an authoritative source of information considered to be necessary for or likely to promote safe operation of the rotorcraft.

(2) Since the flightcrew is most directly concerned with operation of the rotorcraft, the language and presentation of the flight manual shall be directed principally to the needs and convenience of the flightcrew, but should not ignore the needs of other contributors to safe operation. As used with respect to the RFM, safe operation is construed to include, but not be limited to, operation of the rotorcraft in the manner that is mandatory for, or recommended for, compliance with applicable airworthiness requirements, and with the particular provisions of the operating regulations relating to the rotorcraft's approved performance capabilities.

(3) To serve its intended purpose, therefore, the RFM must include the certificate limitations established for the design as a consequence to the type certification evaluation, the performance information necessary to establish the operating limitations imposed in accordance with appropriate operating regulations, and the procedures and other information necessary to enable the flightcrew to safely operate the rotorcraft within the envelope of limitations thus delineated. The outline presented in this circular is directed toward those objectives.

(4) Information and data that are mandatory for an acceptable RFM are prescribed in §§ 29.1581 through 29.1589, and nothing contained in these sections should be construed as amending those requirements. Certain additional elements of flight manuals, however, have been shown by experience to be practical necessities if the document is to serve effectively its intended purpose.

b. Procedures.

(1) The following criteria do not affect the status of RFMs which are presently approved. When such manuals are amended in the future, however, it is recommended that the concepts of this section be incorporated wherever uniformity or clarity will result.

(2) Only the material required by FAR Part 29, or that considered necessary to implement the operating regulation, should be included in the portion of the manual that is approved by the FAA. However, the manufacturer or operator may include other "unapproved" data in a separate and distinctively identified portion within the same document. *

* The RFM is considered necessary for safe operation of the rotorcraft and care should be taken to produce a manual that is consistent with the need for completeness and clarity of the required information. Also, since the RFM is necessary for operation of the rotorcraft in accordance with the certificate limitations, it is considered to be public information.

(3) The page size for the RFM will be left to the discretion of the manufacturer. In this regard, operational compliance with § 91.31 should be considered. A cover should be provided and should indicate the nature of the contents by means of the title, "RFM." Each page of the approved portion should bear the notation "FAA approved," an induction of the approval sequence of that particular page (e.g., a date of approval, a revision number suitably supported by an amendment log which contains the appropriate date, etc.), the helicopter model number as it appears on the type data sheet, and any appropriate document identification number. Pages of the unapproved portion of the flight manual would use the issue date in lieu of the FAA approved date. The material should be bound in semipermanent fashion so that the pages will be protected and retained in proper sequence. In selecting the form of binding, consideration should be given to the necessity for amendment and the ease with which amendments can be accomplished.

(4) Amendments may take the form of revisions or supplements.

(i) A revision is a change to the RFM or its supplement made by the holder of the applicable type certificate (TC) or in the case of supplement prepared as a part of a supplemental type certificate (STC), by the holder of the STC.

(ii) A supplement is an addition to the RFM. If the helicopter manufacturer (holder of the TC) adds optional equipment or specific operations (such as Category "A" vertical operation or IFR operations), then the helicopter manufacturer is responsible for preparing any necessary flight manual material whether he elects it to be a supplement or a revision to the basic manual. If someone other than the helicopter manufacturer applies for an STC to install equipment or modify the helicopter such that a RFM supplement is necessary, then the person who applies for the STC is responsible for the preparation of the RFM supplement.

(5) "Revision" may be incorporated by inserting new pages which embody the amended text and, where applicable, by removing superseded pages. A vertical amendment bar should be inserted in the outer margin, where practicable, to indicate those parts of the text that have been changed. Each amended page should be identified in the same manner as pages of the basic manual, and in addition should carry an identification of its approval sequence.

(6) Supplements are incorporated in the manual by inserting the applicable pages which contain the information associated with the particular change. Each supplemental page should also identify the helicopter type and model flight manual for which the supplement was issued, the name of the issuer, and the FAA approval date. The following statement is an example of a note which*

* would be included on the title page of a flight manual supplement: "For helicopters approved to operate in accordance with the provisions of the helicopter flight manual supplement, the information contained herein supplements the information of the basic flight manual. For limitations, procedures, and performance data not contained in this supplement, consult the basic flight manual."

(7) Supplements should contain as much of the flight manual contents outlined below as considered appropriate for the particular change in type design, including title page and index of contents. It is suggested that these be prepared with a view to insertion in the FAA-approved portion of the flight manual as a complete and self-contained unit.

(8) The RFM should contain as much of the information required in Part 29 as is applicable to the individual type and model. For the purpose of standardization, it is recommended that the sequence of sections and of items within sections, follow the format presented at the end of this paragraph if practicable.

(9) The following information would normally be included in the introduction section of the flight manual.

(i) Title Page. This page should include the manufacturer's name and address and the helicopter model number as it appears on the type certificate data sheet. If desired, include a trade name or trade model number in quotes, provisions for rotorcraft serial number and registration number, approval date of the basic document, and title and signature of the FAA approving official.

(ii) Table of Contents. An index should be located at the front of each section or at the front part of the manual.

(iii) Amendment Log. This log should be in the form of a table with provisions to record, for each amendment, an identifying number, title or description, the page numbers involved, the issue date, the identification of the FAA approving official, and the FAA approval date.

(iv) Separate amendment logs should be provided for each type of amendment issued; i.e., Log of Revisions, Log of Supplements, etc. Amendments issued by other than the holder of the basic type certificate should include a separate amendment log which, in addition to the issue date, should also identify the issuer and the STC number or other approval basis for the associated modification.

(v) List of Current Pages. This table should list, for each approved page of the manual, the issue date and any other appropriate identification necessary to establish that the manual is complete and current.

(10) The following flight manual format would be acceptable. The format recommends a sequence of sections and suggests items which would be included in those sections.

FLIGHT MANUAL FORMAT

* INTRODUCTION

PART I, FAA APPROVED

Section 1	Limitations
Section 2	Normal Procedures
Section 3	Emergency Malfunction Procedures
Section 4	Performance Data
Section 5	Optional Equipment Supplements

PART II, MANUFACTURER'S DATA

Section 6	Weight and Balance
Section 7	Systems Description
Section 8	Handling, Servicing, and Maintenance
Section 9	Supplemental Performance Information

INTRODUCTION: This section would include any signature pages, list of approved pages, the log of revisions, and any additional introductory information desired. For each section, it is suggested that the following major titles be utilized and that the recommended information listed under each title be incorporated. Each section should include a table of contents and a list of figures applicable to that particular section.

Section 1 - Limitations:

a. Kinds of Operation.

Under this heading, crew requirements, VFR and/or IFR flight authorizations, and any operational restrictions would be presented.

b. Flight Limitations.

This section would include limitations with respect to airspeed, altitude, ambient temperatures, wind, slope, prohibited maneuvers, and any other flight limitations associated with a particular helicopter (i.e., HV limitations for Part 29 Category A helicopters). *

* c. Weight Limitations.

This section would contain all gross weight, center of gravity (both longitudinal and lateral) limitations, and any other weight limitations unique to the helicopter (i.e., crew, passenger and/or cargo loadings, WAT limitations for Part 29 helicopters, etc.)

d. Powerplant Limitations.

This section would include the temperature and pressure limits associated with powerplant operation; i.e., torque, r.p.m., TOT, etc. This section would also include approved fuels and oils and their temperature and pressure limits. Any accessories attached to the powerplant (i.e., starters, generators, etc.), to which limitations in starting or operation are applicable, would be included herein.

e. Rotor Limitations.

This would include the power-on and power-off r.p.m. limits, the effect of altitude on these parameters, and any other limitations associated with the rotor system(s).

f. Drive System Limitations.

This section would include all limitations associated with the drive system (i.e., main transmission, any adapter gear boxes, tail rotor gearbox, and any other drive system component applicable to a particular helicopter).

g. System Limitations.

This section would include any particular system limitations unique to the helicopter (i.e., battery limitations, hydraulic system limitations, and any limitations associated with the various types of stability augmentation and/or automatic flight control systems).

h. Instrument Markings.

All instrument markings would appear in this section. The significance of each limitation and of the color coding would be explained in this paragraph.

i. Placards.

The exact wording and general location of all placards pertaining to flightcrew function or cargo loading would appear in this section. *

* Section 2 - Normal Procedures:

a. Preflight Checks.

This paragraph would include any exterior, interior, and any system checks prior to starting the engine(s).

b. Engine Start.

This paragraph would include any procedures associated with the engine start(s).

c. System Checks.

This paragraph would include any system check procedures such as hydraulic, stability augmentation, electrical, flight control, etc., which should be accomplished prior to takeoff.

d. Takeoff.

This paragraph would include any procedures associated with the takeoff and any procedures unique or applicable to the takeoff profile.

e. Cruise and/or Level Flight.

This paragraph would include any procedures applicable to cruise and/or level flight operation.

f. Approach and Landing.

This paragraph would include any procedures required or recommended for the approach and landing duration of the helicopter operation.

g. Engine/Rotor Shutdown.

This paragraph would include any procedures applicable to the engine and/or rotor shutdown and any procedures applicable upon completion of the helicopter operation.

h. Miscellaneous Procedures.

This section would include procedures for miscellaneous systems or conditions, such as bleed air heater, anti-ice systems, cold weather operations, etc.

Section 3 - Emergency and Malfunction Procedures:

a. Introduction.

This paragraph would include any introductory type information (i.e., definitions of terms used and any other information the manufacturer deemed appropriate).

* b. Powerplant Failures.

This paragraph would include any information relative to engine, fuel control, or any other powerplant related emergency or malfunction.

c. Drive System Failures.

This paragraph would include recommendations and procedures relative to any drive system failure and/or malfunction.

d. System Failures.

This paragraph would include procedures and recommendations relative to any system failure and/or malfunction (i.e., electrical, hydraulic, and augmented flight control systems).

e. Fire.

This paragraph would include procedures to be followed in the event that engine, cabin, baggage compartment fire or smoke is detected.

f. Emergency Egress.

This paragraph would include emergency evacuation procedures for both the flightcrew and the passengers.

Section 4 - Performance Data:

a. Power Assurance.

This section would include all information relative to the power assurance checks.

b. Hover Information.

This paragraph would include all information relative to hover performance (i.e., hover ceiling IGE and OGE for single and/or multiengine operation). Any relative wind effects would also be included.

c. Takeoff and Landing and Climb Performance.

This paragraph would include information relative to the takeoff and landing profiles (i.e., HV curves, normal climbs, autorotation speeds, takeoff and landing distance over 50-foot obstacles, and any other data applicable to the particular helicopter).

d. Airspeed Calibration.

This paragraph would include the airspeed calibrations required for the particular helicopter.

* Section 5 - Optional Equipment Supplements:

This section would include all optional equipment supplements. These supplements may modify any of the limitations, procedures (both normal and emergency), and performance characteristics of the basic helicopter.

PART II, Manufacturer's Data (Not FAA Approved)

Section 6 - Weight and Balance:

All supplemental weight and balance information such as crew tables, passenger tables, fuel and oil tables, cargo tables, and any other loading tables applicable to the particular helicopter would appear in this section.

Section 7 - Systems Description:

This section would include all information relative to the various helicopter systems that the manufacturer believes would apply to the particular helicopter.

Section 8 - Handling, Servicing, and Maintenance:

This section would include all information relative to the handling, servicing, and maintenance that the manufacturer would care to present. This section would also include dimensions (i.e., baggage areas, doors, and any internal, external information appropriate to the helicopter).

Section 9 - Supplemental Performance Information:

This section would include any supplemental performance information the manufacturer would wish to provide. This section would also contain the cruise-range information associated with IFR operation. *

* 763. § 29.1583 (through Amendment 29-19) OPERATING LIMITATIONS.

a. Explanation. The purpose of this section is to present the limitations applicable to the rotorcraft type and model as established in the course of the type certification process. The limitations should be presented without explanations other than those explanations prescribed in Part 29. To the maximum practicable extent, the limitations should be presented in "operations" language and format. Since operation of the rotorcraft in accordance with such limitations is required by the operating regulations, the following should be inserted as a note at the beginning of this section: "Operation in compliance with the limitations presented in this section is required by the Federal Aviation Regulations." Section 29.1583 merely states that certain information must be given. The specific information is found during the showing of compliance with other paragraphs in the regulation.

b. Procedures.

(1) Section 29.1545 gives the markings required for the airspeed indicator.

(2) Rotor limits are established during compliance with § 29.33. The markings are specified in § 29.1549.

(3) Powerplant limits are discussed under §§ 29.1549 through 29.1553.

(4) Weight limitations are specified in § 29.25. In the operating limitations section, there should be a statement of the maximum and minimum certificated takeoff and landing weights. For those weight limitations that vary with altitude, temperature, or other variables, the variation in weights may be given in the form of graphs in the performance section of the manual and included as a limitation by specific reference in the limitation section to the appropriate graph or page.

(5) Center of gravity limits are determined in accordance wth § 29.27 and may be presented in the same manner as prescribed for the weight limitations (i.e., a statement under "center of gravity limits" in the limitations section which references graphs or page numbers in the performance section). If landing gear position can measurably effect allowable c.g., this information should be presented together with the moment change due to gear retraction.

(6) The minimum flightcrew is determined under § 29.1523 and is dependent upon the kinds of operation authorized. The established number and identity, by crew position of the minimum flightcrew, must be listed.

(7) Kinds of operations are established under § 29.1525. This section should contain the following preamble: "This rotorcraft is certified in the Transport Category (A and/or B) and is eligible for the following kinds of operation when the appropriate instruments and equipment required by the •

* airworthiness and/or operating rules are installed and approved and are in operable condition." Those of the following, and any others that are applicable, should be listed.

(i) Day and night VFR.

(ii) Approved to operate in known icing conditions.

(iii) IFR.

(iv) Category A vertical operations from ground level or elevated heliports.

(v) Extended overwater operations (ditching).

(vi) External load operations.

(8) Limiting heights and speeds are determined under § 29.1517 and are presented in the form of a height versus velocity diagram in the limitations section for Category A rotorcraft and in the performance section for Category B rotorcraft.

(9) Unusable fuel tests are required by § 29.959. When the amount of unusable fuel has been determined, the manufacturer calibrates his fuel quantity system so that when the fuel quantity in the tank is down to the unusable quantity, his fuel gage will read "zero." A statement should appear in the limitations section to warn the pilot that the quantity of fuel remaining in the tanks when the gage reads zero is not usable in flight.

(10) Often other limitations are included in the limitations section that are not specifically mentioned in the rules but which are necessary for safe operation. Examples are:

(i) Altitude limits.

(ii) Ambient temperature limits.

(iii) Conditions for use of rotor brake.

(iv) Prohibitions against prolonged hover in cross or tail winds to prevent accumulation of noxious fumes in cockpit or cabin.

(v) Prohibitions against acrobatic maneuvers.

(vi) Required placards including text and location.

(vii) Special airworthiness equipment installations such as engine out or low rotor r.p.m. warning systems.

* 764. § 29.1585 (through Amendment 29-19) OPERATING PROCEDURES.

a. Explanation. The procedures sections of the manual should contain essential information peculiar to the particular type or model, the knowledge of which may be expected to enhance safety in the kinds of operations for which the type or model is approved. Information or procedures not directly related to airworthiness, or not under control of the crew, should not be included, nor should any procedure which is accepted as basic airmanship.

(1) Procedures information should be presented with respect to normal and emergency procedures. Alternatively, information outside the category of normal procedures may be subdivided into categories described as "abnormal" procedures and "emergency" procedures, as described herein.

(2) Notes, cautions, and warnings may be used to emphasize specific instructions or information in general accord with the following.

(i) "Note" should be used with respect to matters not directly related to safety but which are particularly important (e.g., Note: For normal twin-engine operation, maximum permissible torque needle split is 4 percent total).

(ii) "Caution" should be used with respect to safety matters of a secondary order not immediately imminent (e.g., Caution: On engine restart reduce ITT to 750° C on the operating engine).

(iii) "Warning" should be used with respect to safety matters of a primary order or imminent (e.g., Warning: Do not allow rotor r.p.m. to drop below minimum limits).

(3) The operating procedures of this section have been developed with specific regard for the design features and operating characteristics of the rotorcraft and have been approved by FAA for guidance in identifying acceptable procedures for safe operation. Observance of these procedures is not mandatory, and FAA approval of such procedures is not intended to prohibit or discourage development and use of improved or equivalent alternate procedures based on operational experience with the rotorcraft. When alternate procedures are used, full responsibility for compliance with applicable airworthiness safety standards rests with the operator.

b. Procedures. Procedural information should be presented in substantial accord with the categories described below:

(1) Normal Procedures. Normal procedures are concerned with peculiarities of the rotorcraft design and operating features encountered in connection with routine operations, including malfunction cases not considered in the other procedures section (i.e., not considered to degrade safety). Material conforming to the above should be presented for each phase of flight, following in sequence from preflight through engine shutdown, and should include, but not be limited to, systems operation (including fuel system information prescribed in 29.1585(b)), missed approaches, etc. *

* (2) Abnormal Procedures (Optional). Abnormal procedures are concerned with foreseeable situations, usually entailing a failure condition, in which the use of special systems, and/or the alternate use of regular systems, may be expected to maintain an acceptable level of airworthiness. Typical examples of events considered to entail abnormal procedures are minor engine malfunctions and associated conditions for safe flight, stopping and restarting engines in flight, extending landing gear or flaps by alternate means, approach with inoperative engine(s), etc.

(3) Emergency Procedures. Emergency procedures are concerned with foreseeable but unusual situations in which immediate and precise action by the crew, as detailed in the recommended procedures, may be expected to reduce substantially the risk of disaster. Typical examples of incidents considered to be emergencies are fire, ditching, loss of tail rotor thrust, etc.

(4) Ditching Procedures. Amendment 29-12 added ditching standards to Part 29. When ditching approval is requested, appropriate procedures and information will be included in the manual. Scale model tests are generally used to prove autorotation "ditching" characteristics and to prove stability in the water (capsize threshold) of the helicopter type design. Many helicopter designs require emergency float bags that deploy either before water contact or shortly after water contact to provide the flotation and stability necessary to comply with the requirements.

(i) Autorotation altitudes and airspeeds and water contact information, if appropriate, derived from or used during the ditching model tests, should be confirmed during FAA flight tests and should be included in the manual. Information concerning sea states or wave heights to length ratios, investigated and found satisfactory, may be included in the manual if nonsevere sea states are likely to be exceeded.

(ii) Instructions for deploying liferafts may be needed for certain designs. For example, if liferafts are stowed outside the cabin, special instructions may be necessary.

(5) Evacuation Procedures for Helicopter Litter Configurations. Appropriate procedures and minimum crew requirements should be considered and included in the manual or manual supplement, if necessary, to assure timely evacuation.

(6) The use of illustrations to show controls, instruments, explain systems, etc., is encouraged. *

* 765. § 29.1587 (through Amendment 29-19) PERFORMANCE INFORMATION.

a. Explanation.

(1) This section would contain the performance information necessary for operation in compliance with applicable performance requirements of FAR Part 29 and applicable special conditions, together with additional information and data essential for implementing pertinent operational requirements.

(2) Performance information and data may be presented for the range of weight, altitude, temperature, and other operational variables stated as operational performance limitations. It is recommended that performance information and data be presented substantially in accordance with the following paragraphs. Where applicable, reference to the appropriate requirement of the certification or operating regulation should be included.

(i) General. Include all descriptive information necessary to identify the configuration and conditions for which the performance data are applicable. Such information may include the complete model designations of rotorcraft and engines, definition of installed rotorcraft features, and equipment that affects performance together with the operative status thereof. This section should also include definitions or terms used in the performance section (i.e., IAS, CAS, ISA, configuration, CDP, V_{TOSS}, Category A, Category B, LDP, etc.) plus calibration data for airspeed, ambient air temperature, and other information of a general nature.

(ii) Performance Procedures. The procedures, techniques, and other conditions associated with obtainment of the flight manual performance should be included, the procedures may be presented as a performance subsection or in connection with a particular performance graph. In the latter case, a comprehensive listing of the conditions associated with the particular performance may serve the objective of "procedures" if sufficiently complete. Performance figures are based on the installed minimum specification engine unless normally depreciated engine performance is approved.

(iii) Wind Accountability. Wind accountability may be utilized for conventional takeoff field lengths. This accountability shall not be more than 50 percent of the nominal wind component along the takeoff path opposite to the direction of takeoff. In some rotorcraft, it may be necessary to discount the beneficial aid to takeoff performance for winds from 0 to 10 knots. This should be done if it is evident that the winds from 0 to 10 knots have resulted in a significant degradation to the takeoff performance due to the washout of the ground effect cushion.

(iv) The following list is illustrative of the information that may be provided for a transport Category "A" and "B" helicopter.

(A) Density altitude chart for converting from pressure to density altitude.

(B) Temperature conversion chart (°C to °F to °C).

* (C) Airspeed calibration (calibrated vs. indicated airspeed) for both pilot and copilot systems for level flight, climb, autorotation, and recommended approach rate of descent.

(D) Altimeter correction for pilot and copilot instruments showing the correction factor vs. indicated airspeed at sea level and altitude.

(E) Hover performance charts both in and out-of-ground effect with instructions for their use. The out-of-ground effect hover performance chart is not required but may be useful.

(F) A series of climb performance charts for various weights showing rate of climb vs. pressure altitude for a range of temperatures and showing the variation of best rate of climb speed with pressure altitude. The conditions should appear on each chart (i.e., power, weight, single, or multiengine, etc.).

(G) A chart showing the takeoff flight path for Category A presented in height vs. distance from the hover wheel height to the point at which V_{TOSS} and not less than 35 feet is reached, and the rejected takeoff distance. The chart should identify the critical decision point and V_{TOSS}.

(H) A chart or series of charts to allow calculation of any additional distance which may be required to accelerate to best rate of climb speed from V_{TOSS}.

(I) Landing distance chart for Category A showing the landing distance from a 50-foot height (25-foot for VTOL operations from an elevated heliport) to a stop with one engine inoperative vs. pressure altitude over the range of temperatures being certified. This chart should identify the balked landing decision point (LDP) so the pilot will know how to achieve this performance.

(J) For Category B, a chart or series of charts at various weights showing takeoff distance from hover to 50 feet vs. pressure altitude over the range of temperatures being certified.

(K) For Category B, a landing distance chart similiar to the one for Category A from a 50-foot height to stop with one engine inoperative.

(L) For turbine powered helicopters in all categories, a power assurance check chart.

(M) A statement of the maximum crosswind and downwind components that have been demonstrated as safe for operation near the ground.

(v) Miscellaneous Performance Data. Any performance information or data not covered in items (A) through (L) above, but considered necessary or for use with the operating procedures contained in the rotorcraft flight manual, should be included. *