These AC sections are additions and replacements to the existing AC sections, to be published in the next change or revision to AC 29-2.

Draft Performance and Handling Qualities - Part 29, AC Material

Amend AC 29.25 by the addition of:

AC 29.25A. § 29.25 (Amendment 29-51) WEIGHT LIMITS.

a. Explanation. Amendment 29-51 added a new paragraph (a)(4) that requires that the operating envelope for the controllability demonstrated under § 29.143(c) be included in the limitations section of the Rotorcraft Flight Manual (RFM). The change allows, in addition to the 17-knot controllability requirements, the applicant to provide additional controllability information within an applicant selected limited azimuth range if the rotorcraft is certified with nine or less passenger seats. This effectively allows increased weights within this limited range. Amendments 29-21 and 29-24 allowed for this relief and subsequent regulatory policy recognized these limitations as they are now required. In no case should those limits be established at an altitude that is not operationally suitable. In the past, the minimum operationally suitable altitude for takeoff and landing has been established as 3,000 feet density altitude.

The explanation regarding the relief for presentation of hover controllability limits in AC 29.143.a.(2)(ii) (Amendment 29-24) is superseded by this change.

b. Procedures.

The policy material pertaining to the procedures outlined in this section remain in effect.

Amend AC 29.49 to be consistent with the new AC 27.49:

AC 29.49 § 29.49 (Amendment 29-39) PERFORMANCE AT MINIMUM OPERATING SPEED. HOVER PERFORMANCE FOR ROTORCRAFT.

The policy material pertaining to this section remains in effect with the following revised parameters to paragraph b.(3):

3) To obtain consistent data, the wind velocity should be 3 knots or less. Large rotorcraft with high downwash velocities may tolerate higher wind velocities. The parameters usually recorded at each stabilized condition are:

(i) Engine and transmission torque.

(ii) Rotor speed.

(iii) Ambient and engine temperatures, such as Measured Gas Temperature (MGT).

(iv) Pressure altitude.

(v) Fuel used (or remaining).

(vi) Load cell reading.

(vii) Generator(s) load.

(viii) Wind speed and direction.

(ix) Hover height.

As a technique, it is recommended the rotorcraft be loaded to a center of gravity (CG) near the hook to minimize fuselage angle changes with varying powers. All tethered hover data should be verified by a limited spot-check using the free flight technique. The free flight technique in AC 29.49.b.(4) will determine if any problems, such as load cell malfunctions, have occurred. The free flight hover data must fall within the allowable scatter of the tethered data.

Amend AC 29.143 by the addition of:

AC 29.143A. § 29.143 (Amendment 29-51) CONTROLLABILITY AND MANEUVERABILITY.

a. Explanation. Amendment 29-51 made a minor clarification to assure that in-ground-effect (IGE) controllability is demonstrated at all wind speeds up to 17 knots, for all azimuths. In many rotorcraft, the entry into the regime of translational lift requires the most power, thus potentially causing control difficulties, and frequently occurs at speeds less than 17 knots. The amendment also requires that out-of-ground-effect (OGE) controllability be determined up to a speed of at least 17 knots at a weight selected by the applicant. The amendment clarifies the intent of Amendment 29-21 and Amendment 29-24 with respect to removing hover controllability as a limit. § 29.25 is amended to assure that appropriate weight limitations are incorporated into the Rotorcraft Flight Manual (RFM) when the relieving provisions of the previous amendments are adopted by an applicant. The previous amendment and associated AC material indicated that certain Category B rotorcraft were relieved from providing, as a limitation, the conditions of § 29.143(c). In practice, the 17-knot controllability requirement was still treated as a limitation, but, as indicated in the amended § 29.25, additional limits could be included, when demonstrated, that allowed for something other than 17-knot all azimuth controllability. The established weight, altitude, and temperature charts, including any associated wind constraints, could be contained in the performance section of the flight manual when the appropriate reference to those charts were included in the limitations section of the RFM. In addition, the relief of Amendments 29-21 and 29-24 were only intended for those category B rotorcraft with nine or less passenger seats.

All the policy material pertaining to this section remains in effect with the following changes:

(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 controllability and for maneuverability are summarized in § 29.143(a) which is 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 rotorcraft, the hover condition clearly applies under "any maneuver appropriate to the type."

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

(i) § 29.143(b) specifies flight at V_{NE} with critical weight, center of gravity (CG), 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° 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) § 29.143(c) requires a minimum control capability for hover and takeoff in winds from zero to at least 17 knots from any azimuth. Control capability in wind from zero 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. Prior to Amendment 29-24, hover controllability, height-velocity, and hover performance were the three regulatory requirements that ordinarily determined the shape of the limiting weight-altitude-temperature (WAT) curve for takeoff and landing. For Category A performance rotorcraft operations, of course, the one-engine-inoperative (OEI) climb performance requirements may also influence the WAT limit curve. Amendment 29-24 allows, under certain conditions, the deletion of any hover controllability condition determined under § 29.143(c) from becoming an operating limitation. § 29.1587 of Amendment 29-24 provides a means wherein Category B certificated rotorcraft (in accordance with the requirements of § 29.1, effective with Amendment 29-21) may not be limited by the hover controllability requirements of § 29.143(c). § 29.1583(g) requirements for Category A certificated rotorcraft are unchanged from past regulatory requirements in that if the hover controllability requirements of § 29.143(c) result in the most restrictive envelope it will be published as an operating limitation. § 29.1587(b) provides a means wherein Category B certificated rotorcraft, as defined in § 29.1, may not be restricted in its utilization. § 29.1587(b) allows some Category B RFMs to include maximum takeoff and landing performance information, provided that something other than the 17-knot hover controllability requirement is not limiting. This may be zero wind IGE hover performance or any other performance the applicant elects to use, if the maximum safe wind for operations near the ground is provided. Rotorcraft certificated prior to Amendment 29-24 can update their certification basis to take advantage of this provision. If an applicant with a previously type certificated rotorcraft elects to update to this later amendment, caution should be taken to verify that the height-velocity information is done in accordance with Amendment 29-21; that all engine out landing capabilities are satisfactorily accounted for at the new proposed gross weight, altitude, temperature combinations; that takeoff/landing information is provided; and that sufficient information is provided to properly advise the crew of the rotorcraft's capabilities when utilizing this increased performance capabilities.

(iii) § 29.143(e) 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 that 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 (MCP) (or takeoff power where appropriate) including reasonable engine torque splits. For multiengine Category A installations with three or more engines, the 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 MCP 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 powerplant installation rotorcraft, 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, and climb at V_Y. MCP is specified prior to the failure for the cruise condition. Power levels appropriate to the maneuver should be used for other conditions. The corrective action time delay for the cruise failure should be 1 second or normal pilot reaction time (whichever is greater). Cyclic and directional control motions which are part of the pilot task of flight path control are normally not subject to the 1-second restriction; however, the delay is always applied to the collective control for the cruise failure. If the aircraft flying qualities and cyclic trim configuration encourage routine release of the cyclic control to complete other cockpit tasks during cruise flight, consideration should be given to also holding cyclic fixed for the 1-second delay. Although the same philosophy could be extended to the directional controls, the likelihood of the pilot having his feet away from the pedals is much lower, unless the aircraft has a heading hold feature. Rotor speed at execution of the cruise condition power failure should be the minimum power-on value. The term "cruise" also includes cruise climb and cruise descent conditions. Normal pilot reaction times are used elsewhere. Although this requirement specifies MCP, it does not limit engine failure testing to MCP. 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, the rotor speed, flapping, and aircraft dynamic characteristics must stay within structurally approved limits.

(iv) § 29.143(f) 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).

(v) 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° 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) and § 29.175(c), and to 1.1 V_{NE} (power-off) in autorotation per § 29.143(f) 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 rotorcraft was certificated with a rate of descent limitation to preclude operation in the control-limited area.

(vi) An evaluation of the emergency descent capability of the rotorcraft 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 or other similar failure. Each rotorcraft 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. If the time period does not permit a sea level landing, the maximum height above the terrain must be specified in the limitation section of the RFM.

(3) The required controllability and maneuvering capabilities must also be considered following the failure of automatic equipment used in the control system (§ 29.672). Examples include stability augmentation systems (SAS), stability and control augmentation systems (SCAS), automatic flight control systems (AFCS), devices to provide or improve longitudinal static stability such as a pitch bias actuator (PBA), yaw dampers, and fly-by-wire elevator or stabilator surfaces. These systems all use actuators of some type, and they are subject to actuator softover and hardover malfunctions. The flight control system should be evaluated to determine whether an actuator jammed in an extreme position would result in reduced control margins. Generally, if the flight control system stops are between the actuator and the cockpit control, the control margin will be affected. If the control stops are between the actuator and the rotor head, the control margins may not be affected, but the location of the cockpit control may be shifted. This could produce interference with other items in the cockpit. An example of this would be a lateral actuator jammed hardover causing a leftward shift in the cyclic stick position. Interference between the cyclic stick, the pilot's leg, and the collective pitch control could reduce the left lateral control available and reduce left sideward flight capability. In the case of fly-by-wire surfaces, both the high speed forward flight controllability and the rearward flight capabilities could be affected. Flight control systems that incorporate automatic devices should be thoroughly evaluated for critical areas. Every failure condition that is questionable should be flight tested with the appropriate actuator fixed in the critical failure position. These failures may require limitations of the flight envelope. Any procedure or limitation that must be observed to compensate for an actuator hardover or softover malfunction should be included in the RFM.

b. <u>Procedures</u>.

<u>The policy material pertaining to this section remains in effect with the following changes and additions</u>:

(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/CG variation as fuel is burned.

(2) The critical condition for V_{NE} controllability testing is ordinarily aft CG, 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 MCP would not produce the same results obtained at the same density altitude at colder ambient temperatures where maximum continuous torque would be limiting. Forward CG 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) Controllability

(i) The critical condition for controllability testing in a hover is ordinarily forward CG at maximum weight with minimum power-on rotor RPM. For rearward flight testing of configurations where the forward CG limit varies with weight, low or high gross weight may be critical. Lateral CG 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. IGE hover controllability testing should be accomplished with the lowest portion of the rotorcraft at the published hover height above ground level; however, the test altitude above the ground may be increased to provide reasonable ground clearance. OGE testing should be done with the rotor at a predetermined height above the ground at which it has been determined that there is no ground effect. 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 rotorcraft is held in the most critical position relative to wind.

(A) Testing will normally be carried out at the power required to achieve stabilized flight conditions. However, it is also important to show that yaw control remains adequate to allow normal power changes that might be required in normal operational maneuvers typical for the type and use of the rotorcraft. With rotorcraft that are operating in conditions in which the gross weight is limited by the power available, there should always be adequate tail rotor pedal control available to maintain yaw control when using up to Take-off Power. However, this will not be the case if the rotorcraft weight in the low speed flight envelope is limited by yaw control system capability. There may be other conditions where adequate yaw control is not available at high power, for example a rotorcraft which is limited by the CAT A weight (for rotorcraft certificated to § 29.1 (c)).

(B) To cover the case where excess power is available, it is appropriate to examine the rotorcraft characteristics with some small amounts of additional power applied. This will account for typical power variations that will be experienced during normal use of the rotorcraft. For example, maneuvering or turbulence will cause the pilot to use some of the excess power available. The rotorcraft should be flown, both IGE and OGE, with the most adverse wind speed and direction for directional control within the flight envelope proposed. Use power variations above trim that might be expected during normal use of the rotorcraft giving consideration to the amount of excess power available, the ease with which power can be controlled by collective, and the characteristics of the rotorcraft if the limits of directional control are approached. There should be no tendency to deviate rapidly or suddenly in yaw. This assessment is normally conducted in conjunction with the critical azimuth testing.

(C) It may be appropriate to provide flight manual information on the directional control characteristics, including any relevant maximum power above which it could be expected that directional control might not be maintained.

(ii) Comprehensive controllability tests are typically conducted at low, intermediate (~7000 feet Hd), and high tests sites, with prepared landing surfaces, in conjunction with takeoff, landing, and performance testing.

(iii) Alternatively, a predicted controllability model developed for high altitude may be used if verified by limited flight testing with steady ambient winds. The extrapolation guidelines in AC 29.45 b(2) are still applicable. These high altitude controllability tests could typically be conducted in conjunction with takeoff, landing and performance tests.

(iv) Controllability can usually be extrapolated up to a maximum of 2,000 feet above the highest test site altitude.

NOTE: Engine operating characteristics must be considered during the limited altitude tests.

(4) Prior to engine failure testing, the pilot should 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 stabilized and minimum transient rotor RPM limits. These values should 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 should 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 exceeding a temperature limitation. 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 conjunction with forward cyclic to correct pitch-up 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 requirements of § 29.143(a)(2)(v) and (vi).

Amend AC 29.173 by the addition of:

AC 29.173A. § 29.173 (Amendment 29-51) STATIC LONGITUDINAL STABILITY.

a. Explanation.

(1) Amendment 29-51 makes a major change to the requirement by allowing for neutral or negative static longitudinal stability in limited flight domains. Additionally, the requirement for the hover demonstration found in § 29.173(c) has been deleted as this requirement is adequately covered by the controllability requirements. The basic tenants of the rule are unchanged in that the rule contains control system design requirements for both stability and control. Paragraph (a) contains the basic control philosophy necessary for all civil aircraft. Forward motion of the cyclic control must produce increasing speeds and aft motion must result in decreasing speeds. For rotorcraft, this is accomplished with throttle and collective held constant. This requirement in no way assures aircraft stability. It is simply a control requirement that

speaks to direction of control motion. Rotorcraft with either highly stable or highly unstable static longitudinal stability characteristics can typically comply with the basic requirement for control sense of motion.

All the policy material pertaining to this section remains in effect with the following changes and additions:

(2) §§ 29.173 through 29.175 contain the basic control position requirements necessary to establish a minimum level of static longitudinal stability. Positive stability is found for conditions of climb, cruise, V_{NE}, and autorotation in § 29.175 by demonstrating a stable stick position gradient through a specified speed range. This is the primary method of demonstrating compliance with the longitudinal static stability requirements.

(3) For aircraft that do not possess positive control position stability for some limited flight conditions or modes of operation, an equivalent level of safety was previously provided that requires a qualitative evaluation of the pilot's ability to maintain a given airspeed within 5 knots of the desired speed without exceptional piloting skill or alertness. These flight conditions and modes of operation could include various combinations of gross weight, CG, flight regime (climb, cruise, descent), ambient conditions (altitude/temperature), as well as possible variations in the stability augmentation configuration. In the past, the FAA/AUTHORITIES have certified numerous rotorcraft, under equivalent level of safety findings, which have neutral or negative static longitudinal stick position stability in some flight domains. This amendment to § 29.173 is intended to allow for this case without having to resort to an equivalent safety finding. For these previous equivalent safety findings, acceptable qualitative flight characteristics were found on aircraft which possessed negative longitudinal stick position gradients of up to 2-3% of total control travel in certain flight regimes; however, this value is not intended to be a limit. When this means of compliance is elected by the applicant, in addition to the qualitative pilot evaluation it is still necessary to collect the data associated with the classical static longitudinal stability testing as defined in § 29.175.

b. Procedures.

All the policy material pertaining to this section remains in effect with the following changes and additions:

(1) The control requirement of paragraph (a) of this section is so essential to basic flight mechanics that compliance may be found during conventional flight testing for compliance with other portions of the regulations. No special or designated testing should be required.

(2) The procedures necessary to assure compliance with the primary stability requirements of this section are contained under § 29.175, Demonstration of Static

Longitudinal Stability. Refer to AC 29.175A of this advisory circular for an explanation of detailed flight test procedures.

(3) The procedures necessary to assure compliance with the alternative (i.e., pilot evaluation) method of compliance are provided below.

(i) For those limited conditions where compliance with the basic control position requirements cannot be shown, the evaluation must focus on the ability of the pilot to maintain airspeed in the flight regime without exceptional piloting skill or alertness under typical flight conditions. “Limited flight conditions” infers that the aircraft should be in reasonable compliance with the stick position stability requirements of § 29.173(b) for most of the flight conditions and configurations tested. Extraordinary means of complying with § 29.173(b) should not be forced on the aircraft design if the airspeed retention task meets the pilot skill and alertness guidelines. The demonstration flight regimes are defined in § 29.175(a) through (d). For those flight regimes, conditions, and configurations where compliance with stick position requirements of § 29.173(b) cannot be shown, the evaluation pilot should assess the ease of maintaining airspeed within the specified +/- 5 knots.

(ii) When assessing the ease of maintaining airspeed the total workload must be considered. Secondary tasks pertinent to the minimum flight crew in each flight regime should be conducted. This may include visual navigation and communication in cruise, traffic avoidance in climb, and landing site selection in autorotation.

(iii) The cues that the aircraft provides are an important contributor to the evaluation, and the nature of these cues should be noted in the compliance report where this alternate qualitative evaluation determines that the aircraft has satisfactory airspeed stability characteristics. The cues that supplant the control position cues may be found to be sufficient if these cues are natural to the speed maintenance task, and provide adequate guidance to the pilot during the task. One important cue might be the pitch attitude gradient with speed, where a perceptible change in trimmed pitch attitude is required for a perceptible airspeed change. Where pitch attitude is the predominant cue the relationship should be positive (nose down with airspeed increase) and perceptible without exceptional alertness. With this relationship, the evaluation pilot may find that the natural pitch control tasks associated with attitude control result in adequate airspeed retention, and the aircraft would be found to be in compliance. It may be that the power/airspeed relationship of the aircraft can create adequate cues, where a significant rate of descent is created by a nose down pitch attitude change and a subsequent airspeed increase. In this case, the normal cues associated with altitude retention during fixed power cruise flight may prove to be acceptable for airspeed retention if the evaluation pilot finds that, within the context of the overall flight task, airspeed retention is sufficiently accurate. These altitude change cues may not be usable in autorotation or climb, but may be sufficient in cruise, or V_{NE} tasks.

(iv) Other cues may be found for a specific aircraft, such as small but perceptible changes in noise or vibration. It is not intended that the evaluation pilot search for these cues in order to learn how to maintain airspeed in the aircraft under evaluation. These cues should be perceptible to the typical pilot and sufficient to reinforce the airspeed maintenance task.

Amend AC 29.175 by the addition of:

AC 29.175A. § 29.175 (Amendment 29-51) DEMONSTRATION OF STATIC LONGITUDINAL STABILITY.

a. Explanation. Amendment 29-51 reduces the speed range for the climb and cruise demonstration points of §§ 29.175(a) and 29.175(b), respectively. A new paragraph (c) was added to require an additional cruise demonstration point in order to compensate for the change in reduced speed range in paragraph (b). Additionally, for autorotation, two typically used trim points are required in place of the current requirement. The requirement for the hover demonstration was eliminated for the reasons given in AC 29.173 (Amendment 29-51).

All the policy material pertaining to this section remains in effect with the following changes:

(1) This rule incorporates the specific flight requirements for demonstration of static longitudinal stability. Specific loadings, configurations, power levels, and speed ranges are stated for conditions of climb, cruise, V_{NE}, and autorotation.

(2) Some rotorcraft in forward flight experience significant changes in engine power with changes in airspeed even though collective and throttle controls are held fixed and altitude remains relatively constant. For these cases, the guidance in § 29.173, which states that throttle and collective pitch must be held constant, is appropriate for administration of this rule, and the specified powers in § 29.175 should be considered as power established at initial trim conditions. This will result in slightly higher or lower power readings at “off trim” conditions. Collective and throttle controls are held constant when obtaining test data.

(3) The effects of rotor RPM on autorotative static stability should be determined and positive stability demonstrated for the most critical RPM. For Category A rotorcraft, this requirement may be satisfied at a nominal RPM value. RPM values can be expected to change as airspeed is varied from the “trimmed” condition. The manufacturer’s recommended autorotation airspeed is ordinarily used for trim.

b. Procedures.

All the policy material pertaining to this section remains in effect with the following changes:

(1) Instrumentation.

(i) Sensitive control position instrumentation is mandatory. Engine power parameters should be recorded at trim. For testing of minor modifications or when using a “before and after” method, a tape measure or a stick plotting board may be utilized. A stick plotting board consists of a level surface with a clean sheet of paper on it and is attached to the cockpit or seat structure. The installation must not interfere when the flight controls are fully displaced. A recording pencil is attached to the cyclic control by an offsetting arm in such a manner that it can be pushed down on the board to record relative cyclic position at key times during test maneuvers. The Figure AC 29.175A-1 plot is a typical presentation of longitudinal static stability.

(ii) Other necessary parameters include pitch attitude, pressure altitude, ambient temperature, and indicated airspeed.

(2) Ambient Conditions. Smooth air is necessary for stability testing.

(3) Loading. Aft center of gravity (CG) is ordinarily critical for longitudinal stability testing, although high speed flight should be checked at full forward CG and maximum weight. At aft CG, light or heavy weight conditions can be critical. The manufacturer’s flight data should be reviewed to determine critical loading conditions.

(4) Conducting The Test.

(i) The rotorcraft should be established in the desired configuration and flight condition (climb, cruise, V_{NE}, autorotation) with the required power and rotor speed at the trim airspeed. The collective stick should be fixed in that position; usually by applying sufficient friction to insure that it is not inadvertently moved. For autorotative tests, a rotor speed should be selected so that the variations in rotor speed as airspeed and altitude change do not exceed the allowable limits. This point is recorded as the trim point. Airspeed is then increased or decreased in about 5-knot increments, stabilizing on each speed and recording the data. At least two points on each side of the trim speed should be taken.

(ii) The cruise test should be conducted by varying airspeed around the desired altitude with throttle and collective fixed. This should be accomplished by first determining V_H (level flight speed at maximum continuous power (MCP)) at the test altitude. Then adjust power to establish a level trimmed condition at V_H (or 0.8 V_{NE} if lower). This point is then recorded as the trim point.

(iii) For climb and autorotation tests, conduct fixed collective tests through an altitude band (usually ±2,000 feet). It will probably not be possible to obtain the required data on one pass through the altitude band. If repeated passes are required, a trim point should be taken at the beginning of each pass unless very sensitive collective pitch position information is available in the cockpit.

(iv) If extremely precise results are required, an alternate method of testing can be used to acquire the data at a constant altitude. For cruise and V_{NE}, data can be obtained by alternating airspeeds above and below the trim speed to arrive in the vicinity of the test altitude as the point is recorded. This method results in very precise data because collective and throttle are not moved as airspeed is changed at a constant altitude. A typical sequence of speeds that could produce these results would be: (0.8 V_{NE}) trim speed, 135, 145, 130, and 150.

(v) For rotorcraft with high rates of climb, a series of climbs, each at a different speed, may be required through a given altitude, utilizing sensitive instrumentation to assure collective position is the same for each data point. In autorotation, a similar case arises and a series of descents, each at a different speed, may be required through a given altitude band, using sensitive instrumentation to assure a repeatable collective position.

(vi) Normally tests should be conducted at low, medium, and high altitudes. See AC 29.45 for guidance on interpolation and extrapolation. High speed stability has been critical during cold weather testing. Cold weather testing should be accomplished or a conservative approach for advancing blade tip Mach number should be used to limit cold weather V_{NE} to tip Mach number values demonstrated.

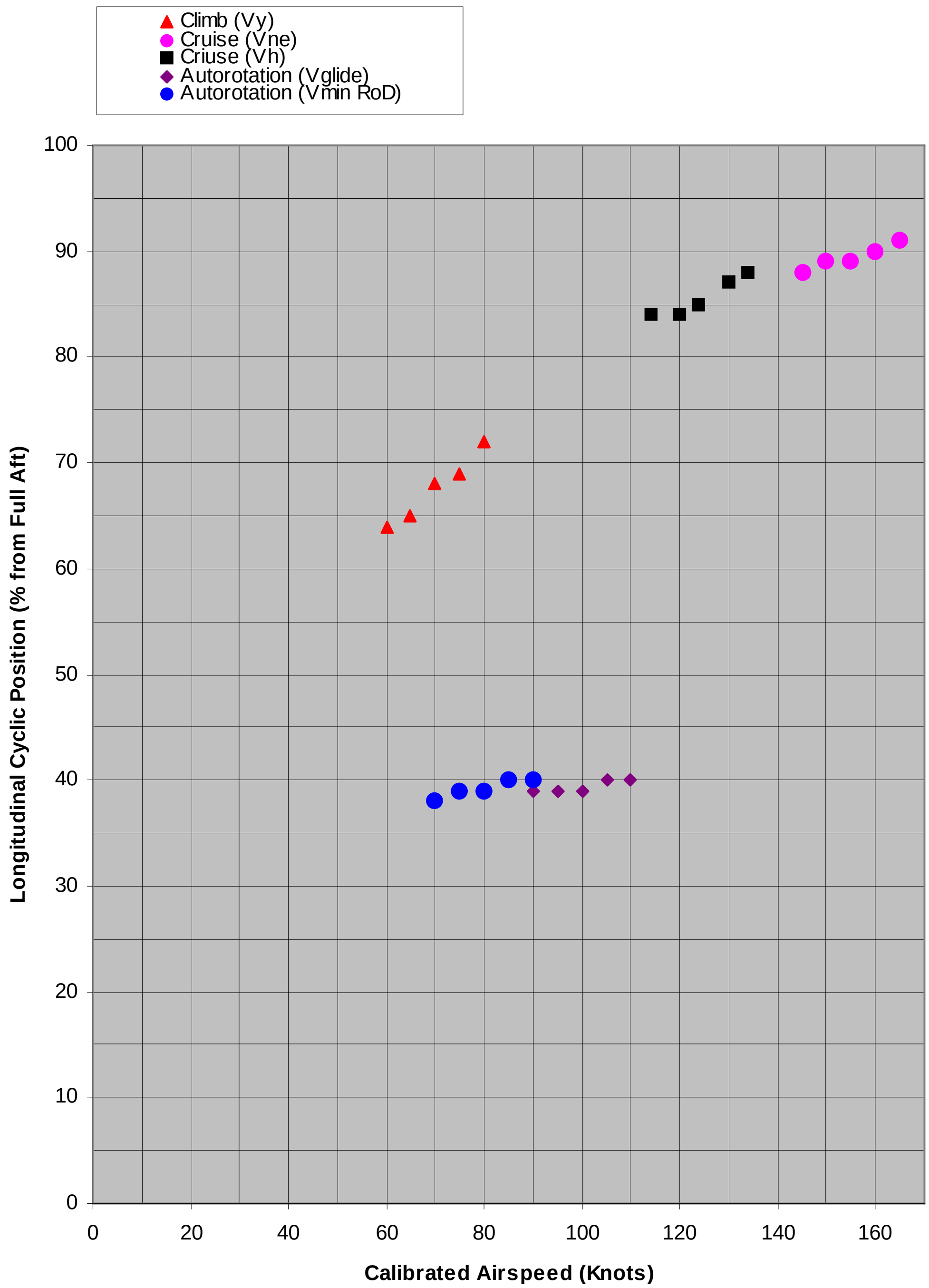

FIGURE AC 29.175A-1 STATIC LONGITUDINAL STABILITY

Amend AC 29.177 by the addition of:

AC 29.177A. § 29.177 (Amendment 29-51) STATIC DIRECTIONAL STABILITY.

a. Explanation. Amendment 29-51 makes an extensive change to the current requirement and provides for a clear definition of the sideslip envelope to be evaluated. Most rotorcraft exhibit satisfactory quantitative and qualitative directional characteristics except for the first 2-3 degrees either side of trim due to inherent airflow blockage of the vertical fin or tail rotor. This amendment takes this blockage into account while requiring that positive directional stability is maintained at larger sideslip angles. The actual demonstration has been increased from a maximum range of ±10° at all speeds, as the previous amendment requires, to ±25° at slow speeds and linearly decreasing to ±10° at V_{NE}. Alternatively to the previous range specified, the requirement limits the maximum sideslip to be demonstrated to at least 0.1g of sideforce or the maximum sideslip attained when full directional control is applied. As in the previous amendment, sufficient cues should alert the pilot when approaching sideslip limits.

b. Procedures.

The policy material pertaining to the procedures outlined in this section remain in effect.

Amend AC 29.1587 by the addition of:

AC 29.1587B. § 29.1587 (Amendment 29-51) PERFORMANCE INFORMATION.

a. Explanation. Amendment 29-51 added the requirement to include in the Rotorcraft Flight Manual (RFM) the maximum weight, altitude, and temperature for which the rotorcraft can safely hover out-of-ground-effect (OGE) in winds of at least 17 knots in all azimuths. This change is in conjunction with the new demonstration requirements of § 29.143(d). Additionally, this change makes clear that the in-ground-effect (IGE) performance with winds of at least 17 knots be included in the RFM.

All the policy material pertaining to this section remains in effect with the following changes:

(1) This section should contain the performance information necessary for operation in compliance with applicable performance requirements of 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. Performance information that exceeds any operating limitation should be shown only as required for clarity of presentation. If data beyond operating

limits are shown, the limits should be clearly marked and the data outside of the limits clearly distinguishable from the data within the limits.

(3) Performance information presented in the unapproved or "manufacturers' data" section of the RFM should not include performance data that are beyond operating limitations unless the particular operating limit that may be exceeded is clearly distinguishable from similar performance data that are within limits. For example, if the weight-altitude-temperature (WAT) limits for takeoff and landing are based on IGE hover performance capability at a 5-foot skid height, 3-foot skid height hover performance data allowing increased hovering weights should not be presented in the manufacturers' data unless clearly identified as being beyond operating limitations for normal operations. 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., indicated airspeed (IAS), calibrated airspeed (CAS), international standard atmosphere (ISA), configuration, critical decision point (CDP), V_{TOSS}, Category A, Category B, landing decision point (LDP), etc.) plus calibration data for airspeed, altimeter, 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 determining takeoff and landing field lengths. This accountability may be up to 100 percent of the minimum wind component along the takeoff or landing path opposite to the direction of takeoff. Wind accountability data presented in the RFM should be labeled "UNFACTORED" (if 100 percent accountability is taken) and should be accompanied by the following note: "Unless otherwise authorized by operating regulations, the pilot is not authorized to credit more than 50 percent of the performance increase resulting from the actual headwind component and must reduce performance by 150 percent of the performance decrement resulting from the actual tail wind component." In some rotorcraft, it may be necessary to discount the beneficial aid to takeoff performance for winds from zero to 10 knots. This should be done if it is evident that the winds from zero to 10 knots have resulted in a significant degradation to the takeoff performance due to flight through the main rotor vortex. Degradation may be determined by ascertaining the power required to fly, by reference to a calibrated pace vehicle, at speeds of 10 knots or less.

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

(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 (IGE) and OGE with instructions for their use.

(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.). The one-engine-inoperative (OEI) climb performance charts at 30-minute power and maximum continuous power (MCP) or at continuous OEI power should provide rate of climb performance down to a minimum of -500 feet/min. The effect of engine air bleed, particle separators, or other devices, on the rate of climb/descent performance must be provided.

(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) Charts to allow calculation of distance to climb at V_{TOSS} from the point at which V_{TOSS} and not less than 35 feet is reached (or from the lowest point of the takeoff profile for elevated heliport) to 200 feet with one engine inoperative and other engines within approved operating limitations. If conservative, providing charts to allow calculation of the total distance from V_{TOSS} and 35 feet to V_Y and 200 feet is allowed.

(I) A 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} with one engine inoperative and other engines within approved operating limitations. If conservative, providing charts to allow calculation of the total distance from V_{TOSS} and 35 feet to V_Y and 200 feet is allowed.

(J) Charts to allow calculation of distance to climb at V_Y from 200 feet to 1000 feet above the takeoff surface (or from the lowest point of the takeoff profile for elevated heliport) with one engine inoperative and other engines at 30-minutes OEI power or maximum continuous OEI power. If conservative, providing charts to allow calculation of the total distance from V_{TOSS} and 35 feet to V_Y and 1000 feet is allowed.

(K) 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.

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

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

(N) For turbine-powered rotorcraft in all categories, a power assurance check chart.

(O) For Category B, a statement of the maximum crosswind and downwind components that have been demonstrated as safe for operation near the ground unless this information is incorporated as an operating limitation. (See AC 29.1583.)

(P) For Category B, the height-velocity (HV) envelope except for rotorcraft which must incorporate the HV diagram as an operating limitation.

(Q) For Category B, the autorotative glide distance as a function of altitude if required by § 29.71. (See AC 29.71.)

(v) Miscellaneous Performance Data. Any performance information or data not covered in items (A) through (Q) above, but considered necessary to enhance safety or to enable application of the operating regulations, should be included.

Amend AC 29 Appendix B by the addition of:

AC 29 Appendix B <u>(Amendment 29-51) AIRWORTHINESS GUIDANCE FOR ROTORCRAFT INSTRUMENT FLIGHT</u>.

a. Explanation. Amendment 29-51 made a change to Section V Static Lateral-Directional Stability that is concurrent with the change to § 29.177 to allow for a small range of sideslip angles (2-3 degrees) for which sideslip angles need not increase steadily with control deflection. The previous rule language stating that directional control position must increase in approximate constant proportion with sideslip angle has been replaced. The intent of this change is that an increase in directional control position must produce an increase in sideslip angle linearly. At greater sideslip angles appropriate to the type, increase in directional control position need not produce a linear increase in sideslip angle but should not become neutral or negative. The change in section VII was a rewrite of the current requirement to clearly state the requirements to be evaluated in the failure case.

b. Procedures.

The policy material pertaining to the procedures outlined in this section remain in effect.