NOTICE OF PROPOSED AMENDMENT (NPA) No 11/2006

DRAFT DECISION OF THE EXECUTIVE DIRECTOR
AMENDING
DECISION NO. 2003/15/RM OF THE EXECUTIVE DIRECTOR
of 14 November 2003 on
Certification Specifications, including airworthiness code and acceptable means of compliance, for Small Rotorcraft (CS-27)

Performance and Handling Qualities Requirements for Small Rotorcraft

TABLE OF CONTENTS.

A. EXPLANATORY NOTE

I. General

1. The purpose of this Notice of Proposed Amendment (NPA) is to envisage amending Decision 2003/15/RM of the Executive Director of 14 November 2003[1]. The scope of this rulemaking activity is described in more detail below.

2. The Agency is directly involved in the rule-shaping process. It assists the Commission in its executive tasks by preparing draft regulations, and amendments thereof, for the implementation of the Basic Regulation[2], which are adopted as "Opinions" (Article 14.1). It also adopts Certification Specifications, including Airworthiness Codes and Acceptable Means of Compliance and Guidance Material to be used in the certification process (Article 14.2).

3. This rulemaking activity is included in the Agency's rulemaking programme for completion in 2006. It implements the rulemaking task 27&29.001 "Performance & Handling Qualities".

4. The text of this NPA was originally developed by the Performance and Handling Qualities Harmonisation Working Group (PHQHWG), a group formed under ARAC on the recommendation of both FAA and the JAA Rotorcraft Steering Group (RSG). It was subsequently further developed by a Drafting Group and the Agency to conform to the rulemaking procedures.

5. The EASA Drafting Group met in October 2004 following closure of the comment period on JAA NPA 27-20, with the objective of reviewing comments received on the JAA NPA, refining the text of the proposals and to ensure co-ordination between EASA and the FAA.

6. This NPA is submitted for consultation to all interested parties in accordance with Article 43 of the Basic Regulation and Articles 5(3) and 6 of the EASA rulemaking procedure[3].

II. Consultation

7. To achieve optimal consultation, the Agency is publishing this draft decision of the Executive Director on its internet site. As the content of this NPA was the subject of a full worldwide consultation through JAA NPA 27-20, the transitional arrangements of Article 15 of the EASA rulemaking procedure apply. This allows for a shorter consultation period of six weeks instead of the standard 3 months and exempts this proposal from the requirement to produce full Regulatory Impact Assessment.

8. Comments on this proposal may be forwarded *(preferably by e-mail)*, using the attached comment form, to:

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[1] Decision No 2003/15/RM of the Executive Director of the Agency of 14.11.2003 on certification specifications for small rotorcraft (« CS-27 »)

[2] Regulation (EC) No 1592/2002 (OJ L 240, 7.9.2002, p.1). Regulation as last amended by Regulation (EC) No 1701/2003 (OJ L 27.9.2003, p. 5).

[3] Decision of the Management Board concerning the procedure to be applied by the Agency for the issuing of opinions, certification specifications and guidance material ("rulemaking procedure"), EASA MB/7/03, 27.6.2003.

By e-mail: NPA@easa.europa.eu

By correspondence: Process Support
Rulemaking Directorate
EASA
Ref: NPA 11-2006
Postfach 10 12 53
D-50452 Cologne
Germany

9. Comments should be received by the Agency before 27 September 2006. If received after this deadline they might not be treated. Comments may not be considered if the form provided for this purpose is not used.

III. Comment response document

10. All comments received in time will be responded to and incorporated in a comment response document (CRD). This may contain a list of all persons and/or organisations that have provided comments. The CRD will be widely available on the Agency's website.

11. The review of comments will be made by the Agency unless the comments are of such a nature that they necessitate the establishment of a group.

IV. Content of the draft decision

12. This NPA contains JAA NPAs 27-20 "Performance and Handling Qualities Requirements for Small Rotorcraft" which had followed and completed the JAA consultation process:

Section B of this EASA NPA is structured with the follows sub-sections:

I. **Explanatory Note** - Describing the development process and explaining the contents of the proposal.

II. **Proposals -** The actual proposed amendments.

III. **Original JAA NPA justification -** The proposals were already circulated for comments as a JAA NPA. This part contains the justification for the JAA NPA.

IV. **JAA NPA Comment Response Document -** This part summarizes the comments made on the JAA NPA and the responses to those comments.

B. JAA NPA 27-20: Performance And Handling Qualities Requirements For Small Rotorcraft

I) Explanatory Note

1. For practical reasons, the initial issue of CS-27 was based upon JAR-27 at Amendment 3. During the transposition of airworthiness JARs into Certification Specifications, however, the rulemaking activities under the JAA system where not stopped and significant rulemaking proposals have since been developed. In order to assure a smooth transition from JAA to EASA, the Agency has committed itself to continue as much as possible the JAA rulemaking activities. It has therefore included most of the JAA rulemaking programme into its own plans. This EASA NPA is a result of this commitment and is based on JAA NPA 27-20 which was circulated for comments from 1 May 2003 till 1 August 2003.

2. This NPA proposes changes to the airworthiness requirements for small rotorcraft, CS-27, due to technological advances in design and operational trends in small rotorcraft performance and handling qualities. It is issued in conjunction with NPA 12/2006, which makes related changes in CS-29. The changes would enhance the safety standards for performance and handling qualities to reflect the evolution of rotorcraft capabilities.

II) Paragraphs Affected

CS 27.25; CS 27.79 (redesignated as CS 27.49); CS 27.51; CS 27.75; CS 27.79; CS 27.143; CS 27.173; CS 27.175; CS 27.177; CS 27.903; CS 27.1587; Appendix B Paragraphs V and VII.

AMC 27.25; AMC 27.49; AMC 27.51; AMC 27.75; AMC 27.79; AMC 27.143; AMC 27.173; AMC 27.175; AMC 27.177; AMC 27.903; AMC 27.1587 and AMC 27 Appendix B.

III) Proposals

The text of the amendment is arranged to show deleted text, new text or a new paragraph as shown below:

1. ~~Text to be deleted is shown with a line through it.~~
2. New text to be inserted is highlighted with grey shading.
3. New paragraph or parts are not highlighted with grey shading, but are accompanied by the following box text:

Insert new paragraph / part *(Include N° and title)*, or replace existing paragraph/ part

4. ….
   Indicates that remaining text is unchanged in front of or following the reflected amendment.

….

Book 1 AIRWORTHINESS CODE

SUBPART B - FLIGHT

1) Amend CS 27.25 by removing the word "or" at the end of the sentence in sub-paragraph (a)(1)(ii); removing the word "and" and adding the word "or" in its place in sub-paragraph (a)(1)(iii); and by adding sub-paragraph (a)(1)(iv) to read as follows:

CS 27.25 Weight Limits

(a) ….

(1) Not more than:

(i) The highest weight selected by the applicant;

(ii) The design maximum weight (the highest weight at which compliance with each applicable structural loading condition of this CS-27 is shown); ~~or~~

(iii) The highest weight at which compliance with each applicable flight requirement of this CS-27 is shown; ~~and~~ or

(iv) The highest weight in which the provisions of CS 27.79 or CS 27.143(c)(1), or combinations thereof, are demonstrated if the weights and operating conditions (altitude and temperature) prescribed by those requirements can not be met; and

….

2) Redesignate CS 27.73 as new CS 27.49 and revise to read as follows:

CS 27.~~73~~49 Performance at Minimum Operating Speed

(a) For helicopters:

(1) The hovering ceiling must be determined over the ranges of weight, altitude, and temperature for which certification is requested, with:

(i) Take-off power;

(ii) The landing gear extended; and

(iii) The helicopter in-ground effect at a height consistent with normal take-off procedures; and

(2) The hovering ceiling determined in sub-paragraph (a)(1) of this paragraph must be at least:

(i) For reciprocating engine powered helicopters, 1219m (4,000 ft) at maximum weight with a standard atmosphere; or

(ii) For turbine engine powered helicopters, 762m (2,500 ft) pressure altitude at maximum weight at a temperature of standard plus 22°C (standard plus 40°F).

(3) The out-of-ground effect hovering performance must be determined over the ranges of weight, altitude, and temperature for which certification is requested, using take-off power.

(b) For rotorcraft other than helicopters, the steady rate of climb at the minimum operating speed must be determined over the ranges of weight, altitude, and temperature for which certification is requested, with:

(1) Take-off power; and

(2) The landing gear extended.

3) Revise CS 27.51 to read as follows:

CS 27.51 Take-off

~~(a)~~The take-off, with take-off power and r.p.m. at the most critical center of gravity, and with ~~the extreme forward centre of gravity~~ weight from the maximum weight at sea-level to the weight for which take-off certification is requested for each altitude covered by this paragraph:

(~~1~~a) May not require exceptional piloting skill or exceptionally favorable conditions throughout the ranges of altitude from standard sea-level conditions to the maximum altitude for which take-off and landing certification is requested, and

(~~2~~b) Must be made in such a manner that a landing can be made safely at any point along the flight path if an engine fails. This must be demonstrated up to the maximum altitude for which take-off and landing certification is requested or 2134m (7,000 ft) density altitude, whichever is less.

~~(b) Sub-paragraph (a) must be met throughout the ranges of:~~

~~(1) Altitude, from standard sea-level conditions to the maximum altitude capability of the rotorcraft, or 2134 m (7000 ft), whichever is less.~~

~~(2) Weight, from the maximum weight (at sea-level) to each lesser weight selected by the applicant for each altitude covered by subparagraph (b)(1).~~

4) Revise CS 27.75(a) to read as follows:

CS 27.75 Landing

(a) The rotorcraft must be able to be landed with no excessive vertical acceleration, no tendency to bounce, nose over, ground loop, porpoise, or water loop, and without exceptional piloting skill or exceptionally favorable conditions, with:

(1) Approach or ~~glide~~ autorotation speeds appropriate to the type of rotorcraft and selected by the applicant;

(2) The approach and landing made with:

(i) Power off, for single engine rotorcraft and entered from steady state autorotation; or

(ii) One-engine inoperative (OEI) for multi-engine rotorcraft, ~~One-engine inoperative (OEI) and~~ with each operating engine within approved operating limitations, and entered from an established OEI approach. ~~; and~~

~~(3) The approach and landing entered from steady autorotation.~~

….

5) Revise CS 27.79(a)(1), (a)(2) and (b)(2) to read as follows:

CS 27.79 Limiting Height-Speed Envelope

(a) ….

(1) Altitude, from standard sea-level conditions to the maximum altitude capability of the rotorcraft, or 2134m (7000 ft) density altitude, whichever is less; and

(2) Weight, from the maximum weight at sea-level to the ~~lesser~~ weight selected by the applicant for each altitude covered by sub-paragraph (a)(1) of this paragraph. For helicopters, the weight at altitudes above sea-level may not be less than the maximum weight or the highest weight allowing hovering out-of-ground effect, whichever is lower.

(b) ….

(1) ….

(2) For multi-engine helicopters, ~~one engine inoperative,~~ OEI, where engine isolation features ensure continued operation of the remaining engines, and the remaining ~~engines at the greatest power for which certification is requested~~ engine(s) within approved limits and at the minimum installed specification power available for the most critical combination of approved ambient temperature and pressure altitude resulting in 2134m (7000 ft) density altitude or the maximum altitude capability of the helicopter, whichever is less, and

(3) ….

….

6) Amend CS 27.143, by removing the word “Glide” and adding the word “Autorotation” in its place in sub-paragraph (a)(2)(v); redesignating sub-paragraphs (d) and (e) as sub-paragraphs (e) and (f) respectively; revising sub-paragraph (c); and adding a new sub-paragraph (d) to read as follows:

CS 27.143 Controllability and Manoeuvrability

(a) ….

(2) ….

(v) ~~Glide~~ Autorotation

….

….

(c) ~~A wind velocity of not less than~~ Wind velocities from zero to at least 31 km/h (17 knots), from all azimuths, must be established in which the rotorcraft can be operated without loss of control on or near the ground in any manoeuvre appropriate to the type, such as crosswind take-offs, sideward flight, and rearward flight~~, with~~:

(1) With altitude, from standard sea-level conditions to the maximum take-off and landing altitude capability of the rotorcraft or 2134m (7000 ft) density altitude, whichever is less; with:

(~~1~~i) Critical Weight;

(~~2~~ii) Critical center of gravity;

(~~3~~iii) Critical rotor rpm;

~~(4) Altitude from standards sea-level conditions to the maximum altitude capability of the rotorcraft or 2134m (7000 ft), whichever is less.~~

(2) For take-off and landing altitudes above 2134m (7000 ft) density altitude with:

(i) Weight selected by the applicant;

(ii) Critical center of gravity; and

(iii) Critical rotor rpm.

(d) Wind velocities from zero to at least 31 km/h (17 knots), from all azimuths, must be established in which the rotorcraft can be operated without loss of control out-of-ground effect, with:
(1) Weight selected by the applicant;
(2) Critical center of gravity;
(3) Rotor rpm selected by the applicant; and
(4) Altitude, from standard sea-level conditions to the maximum take-off and landing altitude capability of the rotorcraft.

(~~d~~e) ….

(~~e~~f) ….

7) Amend CS 27.173 by removing the words "a speed" in the two places in sub-paragraph (a) and adding the words "an airspeed" in both their places; deleting sub-paragraph (c); and revising sub-paragraph (b) to read as follows:

CS 27.173 Static Longitudinal Stability

(a) The longitudinal control must be designed so that a rearward movement of the control is necessary to obtain ~~a speed~~ an airspeed less than the trim speed, and a forward movement of the control is necessary to obtain ~~a speed~~ an airspeed more than the trim speed.

(b) Throughout the full range of altitude for which certification is requested, with the throttle and collective pitch held constant during the manoeuvres specified in CS 27.175(a) ~~to (c)~~ through (d), the slope of the control position versus airspeed curve must be positive ~~throughout the full range of altitude for which certification is requested~~. However, in limited flight conditions or modes of operation determined by the Agency to be acceptable, the slope of the control position versus airspeed curve may be neutral or negative if the rotorcraft possesses flight characteristics that allow the pilot to maintain airspeed within ±9 km/h (±5 knots) of the desired trim airspeed without exceptional piloting skill or alertness.

~~(c) During the manoeuvre specified in CS 27.175(d), the longitudinal control position versus speed curve may have a negative slope within the specified speed range if the negative motion is not greater than 10% of total control travel.~~

8) Amend CS 27.175 by deleting sub-paragraph (d); revising the introductory text in sub-paragraphs (a) and (b); revising sub-paragraphs (b)(3) and (b)(5); redesignating sub-paragraphs (c) as (d) and revising redesignated sub-paragraph (d); and adding a new sub-paragraph (c) to read as follows:

CS 27.175 Demonstration of Static Longitudinal Stability

(a) *Climb*. Static longitudinal stability must be shown in the climb condition at speeds from ~~0.85 Vy to 1.2 Vy,~~ Vy - 19 km/h (10 knots) to Vy + 19 km/h (10 knots), with:
….

(b) *Cruise*. Static longitudinal stability must be shown in the cruise condition at speeds from 0.8 V_{NE} - 19 km/h (10 knots) to 0.8 V_{NE} + 19 km/h (10 knots) or, if V_H is less than 0.8 V_{NE}, from V_H - 19 km/h (10 knots) to V_H + 19 km/h (10 knots) ~~0.7 V_H or 0.7 V_{NE}, whichever is less, to 1.1 V_H or 1.1 V_{NE}, whichever is less,~~ with:

(1) ….

(2) ….

(3) Power for level flight at 0.8 V_{NE} or V_H ~~0.9 V_H or 0.9 V_{NE}~~, whichever is less;

(4) ….

(5) The rotorcraft trimmed at 0.8 V_{NE} or V_H~~0.9 V_H or 0.9 V_{NE}~~, whichever is less.

(c) *V_{NE}*. Static longitudinal stability must be shown at speeds from V_{NE} – 37 km/h (20 knots) to V_{NE} with:

(1) Critical weight;

(2) Critical center of gravity;

(3) Power required for level flight at V_{NE} – 19 km/h (10 knots) or maximum continuous power, whichever is less;

(4) The landing gear retracted; and

(5) The rotorcraft trimmed at V_{NE} – 19 km/h (10 knots).

(~~c~~d) *Autorotation*. Static longitudinal stability must be shown in autorotation at ~~airspeeds from 0.5 times the speed for minimum rate of descent to V_{NE} or to 1.1 V_{NE} (power-off) if V_{NE} (power-off) is established under CS 27.1505 (c), and with:~~

~~(1) Critical weight;~~

~~(2) Critical centre of gravity;~~

~~(3) Power off;~~

~~(4) The landing gear:~~

~~(i) Retracted; and~~

~~(ii) Extended; and~~

~~(5) The rotorcraft trimmed at appropriate speeds found necessary by the Agency to demonstrate stability throughout the prescribed speed range.~~

(1) Airspeeds from the minimum rate of descent airspeed – 19 km/h (10 knots) to the minimum rate of descent airspeed + 19 km/h (10 knots), with:

(i) Critical weight;

(ii) Critical center of gravity;

(iii) The landing gear extended; and

(iv) The rotorcraft trimmed at the minimum rate of descent airspeed.

(2) Airspeeds from the best angle-of-glide airspeed – 19 km/h (10 knots) to the best angle-of-glide airspeed + 19 km/h (10 knots), with:

(i) Critical weight;

(ii) Critical center of gravity;

(iii) The landing gear retracted; and

(iv) The rotorcraft trimmed at the best angle-of-glide airspeed.

~~(d) *Hovering*. For helicopters, the longitudinal cyclic control must operate with the sense, direction of motion, and position as prescribed in CS 27.173 between the maximum approved rearward speed and a forward speed of 31 km/h (17 knots) with:~~

~~(1) Critical weight;~~

~~(2) Critical centre of gravity;~~
~~(3) Power required to maintain an approximate constant height in ground effect;~~
~~(4) The landing gear extended; and~~
~~(5) The helicopter trimmed for hovering.~~

9) Revise CS 27.177 to read as follows:

CS 27.177 Static Directional Stability

~~Static directional stability must be positive with throttle and collective controls held constant at the trim conditions specified in CS 27.175(a) and (b). Sideslip angle must increase steadily with directional control deflection for sideslip angles up to ± 10° from trim. Sufficient cues must accompany sideslip to alert the pilot when approaching sideslip limits.~~

(a) The directional controls must operate in such a manner that the sense and direction of motion of the rotorcraft following control displacement are in the direction of the pedal motion with throttle and collective controls held constant at the trim conditions specified in CS 27.175 (a), (b), and (c). Sideslip angles must increase with steadily increasing directional control deflection for sideslip angles up to the lesser of:
(1) ±25 degrees from trim at a speed of 28 km/h (15 knots) less than the speed for minimum rate of descent varying linearly to ±10 degrees from trim at V_{NE};
(2) The steady state sideslip angles established by CS 27.351;
(3) A sideslip angle selected by the applicant which corresponds to a sideforce of at least 0.1g; or,
(4) The sideslip angle attained by maximum directional control input.

(b) Sufficient cues must accompany the sideslip to alert the pilot when the aircraft is approaching the sideslip limits.

(c) During the manoeuvre specified in sub-paragraph (a) of this paragraph, the sideslip angle versus directional control position curve may have a negative slope within a small range of angles around trim, provided the desired heading can be maintained without exceptional piloting skill or alertness.

Book 1 AIRWORTHINESS CODE
SUBPART E - POWERPLANT

10) Amend CS 27.903 by adding a new sub-paragraph (d) to read as follows:

CS 27.903 Engines

….

(d) Restart capability: A means to restart any engine in flight must be provided.
(1) Except for the in-flight shutdown of all engines, engine restart capability must be demonstrated throughout a flight envelope for the rotorcraft.
(2) Following the in-flight shutdown of all engines, in-flight engine restart capability must be provided.

Book 1 AIRWORTHINESS CODE
SUBPART G - OPERATING LIMITATIONS AND INFORMATION

11) Amend CS 27.1587 by revising the introductory text in sub-paragraph (a) and revising sub-paragraphs (a)(2)(i) and (a)(2)(ii) to read as follows:

CS 27.1587 Performance information

(a) The Rotorcraft Flight Manual must ~~be furnished with~~ contain the following information, determined in accordance with CS 27.~~51~~49 ~~to~~ through CS 27.79 and CS 27.143(c) and (d):

(1) ….

(2) ….

(i) ~~The hovering ceilings and the steady rates of climb and descent, as affected by any pertinent factors such as airspeed, temperature and altitude;~~
The steady rates of climb and descent, in-ground effect and out-of-ground effect hovering ceilings, together with the corresponding airspeeds and other pertinent information including the calculated effects of altitude and temperatures;

(ii) ~~The maximum safe wind for operation near the ground.~~ The maximum weight for each altitude and temperature condition at which the rotorcraft can safely hover in-ground effect and out-of-ground effect in winds of not less than 31 km/h (17 knots) from all azimuths. This data must be clearly referenced to the appropriate hover charts. In addition, i~~I~~f there are other combinations of weight, altitude, and temperature for which performance information is provided and at which the rotorcraft cannot land and take-off safely with the maximum wind value, those portions of the operating envelope and the appropriate safe wind conditions ~~shall be identified in the flight manual~~ must be stated in the Rotorcraft Flight Manual;

….

Book 1 AIRWORTHINESS CODE
APPENDIX B – AIRWORTHINESS CRITERIA FOR HELICOPTER INSTRUMENT FLIGHT

12) Amend Appendix B to CS-27 - Airworthiness Criteria for Helicopter Instrument Flight by revising sub-paragraph (V)(b) by removing the word "cycle" and adding the correct word "cyclic" in its place; and revising sub-paragraphs V(a) and VII(a) to read as follows:

Appendix B to CS-27--Airworthiness Criteria for Helicopter Instrument Flight

….

V. *Static lateral-directional stability*

(a) Static directional stability must be positive throughout the approved ranges of airspeed, power, and vertical speed. In straight~~,~~ and steady sideslips up to ±10° from trim, directional control position must increase ~~in approximately constant proportions to angle of sideslip.~~ without discontinuity with the angle of sideslip, except for a small range of sideslip angles around trim. At greater angles up to the maximum sideslip angle appropriate to the type, increased directional control position must produce an increased angle of sideslip. It must be possible to maintain balanced flight without exceptional pilot skill or alertness.

(b) During sideslips up to ± 10° from trim throughout the approved ranges of airspeed, power, and vertical speed there must be no negative dihedral stability perceptible to the pilot through lateral control motion or force. Longitudinal ~~cycle~~ cyclic movement with sideslip must not be excessive.

….

VII. *Stability Augmentation System (SAS)*

(a) If a SAS is used, the reliability of the SAS must be related to the effects of its failure. ~~The occurrence of any failure condition which~~ Any SAS failure that would prevent continued safe flight and landing must be extremely improbable. It must be shown that for any failure ~~condition~~ of the SAS that is not shown to be extremely improbable:

(1) The helicopter ~~must be~~ is safely controllable ~~and capable of prolonged instrument flight without undue pilot effort. Additional unrelated probable failures affecting the control system must be considered~~ when the failure or malfunction occurs at any speed or altitude within the approved IFR operating limitations; and

(2) ~~The flight characteristics requirements in Subpart B of CS-27 must be met throughout a practical flight envelope.~~
The overall flight characteristics of the helicopter allow for prolonged instrument flight without undue pilot effort. Additional unrelated probable failures affecting the control system must be considered. In addition:

(i) The controllability and manoeuvrability requirements in Subpart B of CS-27 must be met throughout a practical flight envelope;

(ii) The flight control, trim, and dynamic stability characteristics must not be impaired below a level needed to allow continued safe flight and landing; and

(iii) The static longitudinal and static directional stability requirements of Subpart B of CS-27 must be met throughout a practical flight envelope.

….

Book 2 ACCEPTABLE MEANS OF COMPLIANCE
SUBPART B - FLIGHT

13) Proposed AMC material

Proposed AMC material related to the above rule changes is contained in Appendix A of this NPA. This material is considered to be a part of this NPA, and is published for comment in accordance with EASA procedures. In due course, it will be circulated for comment to interested parties in the USA by the FAA. The material (amended as necessary as a result of comments received in response to this NPA and the FAA circulation) will be published in the future in an update to FAA AC 27-1B and will then undergo a further formal consultation process in accordance with EASA procedures before adoption as AMC to CS-27. It is not intended to publish the amended AMC in Book 2 of CS-27 directly.

IV Original JAA NPA Proposals Justification

a) Background

Due to technological advances in design and operational trends in normal and transport rotorcraft performance and handling qualities, the FAA and EASA are proposing new and revised airworthiness standards. Some of the current Part 27/Part 29 and CS-27/CS-29 regulations are outdated and do not reflect, in some cases, safety levels attainable by modern rotorcraft, or FAA and EASA approved equivalent level of safety findings.

b) History

It has been approximately 20 years since the last major promulgation of rules that address the performance and handling qualities of rotorcraft (FAA Amendments 29-24 and 27-21, 49 FR 44433 and 49 FR 44436, November 6, 1984). Since then, the FAA has developed policy and procedures that address certain aspects of these requirements to make the Part 27 and 29 rules workable within the framework of later rotorcraft designs and operational needs. In addition, most manufacturers have routinely exceeded some of the minimum performance requirements in Part 27 and Part 29 of the Code of Federal Regulation (CFR) in order to meet customer needs.

After the publication of the first issue of the Joint Aviation Regulations (JAR) for Parts 27 and 29, which closely mirrored Federal Aviation Regulation (FAR) Part 29 at amendment 31 and FAR Part 27 at amendment 27, the European JAA Helicopter Airworthiness Study Group (HASG) and the FAA agreed to form a specialist sub-group to review proposals on flight matters that were not incorporated during promulgation of the JAR. This sub-group consisted of representatives of the JAA, Association of European des Constructeurs de Material Aerospatiale (AECMA), Aerospace Industries Association of America (AIA), and the FAA. The sub-group first met in January 1994 and presented their findings to the HASG and the FAA in May 1994.

Aviation Rulemaking Advisory Committee (ARAC) Involvement

The FAA announced the formation of the Performance and Handling Qualities Requirements Harmonization Working Group (PHQHWG) in the Federal Register (60 FR 4220, January 20, 1995) to act on the recommendation presented to the HASG and the FAA by the specialist sub-group. The PHQHWG was charged with recommending to ARAC new or revised standards for flight-test procedures and requirements. The PHQHWG was tasked to "Review Title 14 Code of Federal Regulations Part 27 and Appendix B, and Part 29 and Appendix B, and supporting policy and guidance material for the purpose of determining the course of action to be taken for rulemaking and/or policy relative to the issue of harmonizing performance and handling qualities requirements."

The PHQHWG included representatives that expressed an interest by responding to the notice the FAA published in the Federal Register. The PHQHWG included representatives from the AIA, the AECMA, the European JAA, Transport Canada, and the FAA Rotorcraft Directorate. Additionally, the PHQHWG consulted representatives from the manufacturers of small rotorcraft. This broad participation is consistent with the FAA policy to involve all known interested parties as early as practicable in the rulemaking process. The PHQHWG first met in March 1995 and has subsequently met nine times.

c) Discussion of Proposals

General

Using the report submitted to the HASG as a starting point, the PHQHWG agreed there was a need to update the rotorcraft performance and handling qualities standards. As the meetings progressed, the group evaluated additional internally generated proposals to change the performance and handling qualities requirements that were believed to be pertinent to the group's task. These proposals were either accepted or rejected on their merits and by consensus of the group. The group also came to a common understanding of some acceptable methods of compliance for the proposals as well as the current requirements, and appropriate Advisory Circular material was developed concurrently with this proposed rule.

There was much discussion in the working group about the evolution of the Appendix B Instrument Flight Rules (IFR) flight characteristic requirements. Early IFR helicopters were developed using relatively simple analog systems consisting primarily of two or three-axis rate damping with, in some cases, attitude or heading hold features. Today, there are complex digital automatic flight control systems or flight management systems available with highly redundant system architectures. These highly complex systems may have enough redundancy or compensating features to allow system operating characteristics as well as acceptable aircraft handling qualities to be maintained in degraded modes of operation. Due to the difficulty of adequately addressing all the various elements of these complex systems and the associated flight characteristics, it was decided not to initiate Parts 27 and 29 rulemaking addressing these complex systems at this time, and that the certification requirements for these types of complex systems would be handled on a case-by-case basis within the current regulatory structure.

Proposal 1 - CS 27.25 Weight Limits

Sub-paragraph (a)(1)(iv) would be added to formalize the equivalent level of safety findings by establishing a maximum weight limit if the requirements in CS 27.79 or 27.143(c)(1) cannot be met. Some recent certifications of Part 27 rotorcraft have required placing weight, altitude, and temperature limitations in the Rotorcraft Flight Manual (RFM) to achieve an equivalent level of safety with certain flight requirements. Specifically, the requirement for controllability near the ground while at maximum weight and 7,000 feet density altitude and the requirement to establish the height-speed envelope at maximum weight or the highest weight allowing for hover out-of-ground effect (OGE) for altitudes above sea-level are considered a minimum level of safety for small rotorcraft. If compliance with these minimum standards is reached, the resultant data is put in the flight manual as performance information. In some cases, an equivalent level of safety has been attained by prohibiting certain operations and including limitations in the RFM that reflect the actual capability of the rotorcraft.

Proposal 2 - New CS 27.49 Performance at Minimum Operating Speed (formerly 27.73)

This proposed rule would redesignate CS 27.73 as CS 27.49 and add a requirement to determine the OGE hover performance. Installed engine power available on normal category helicopters has increased significantly since the promulgation of the original Part 27 requirement, particularly for hot-day and high-altitude conditions. As a result, OGE helicopter operations once limited to special missions have become common. Most manufacturers present OGE hover performance data in approved flight manuals, although these data are not currently required. This change would mandate the current industry practice and require that OGE hover data be determined throughout the range of weights, altitudes, and temperatures.

Proposal 3 - CS 27.51 Take-off

The proposed rule would revise the wording of CS 27.51 to recognize that the most critical center-of-gravity (CG) may not be the extreme forward CG, and would require that tests be performed at the most critical CG configuration and at the maximum weight for which take-off certification is requested. The current standard requires that tests be performed at the extreme forward CG and at a weight selected by the applicant for altitudes above sea-level. Although for most rotorcraft the extreme forward CG is most critical, this may not be true for all rotorcraft, and the proposed language would provide for such possibilities. This change to CS 27.51 more clearly states the intent of the current rule, which is to demonstrate engine failure along the take-off flight path at the weight for which take-off data are provided. The requirement to demonstrate safe landings after an engine failure at any point along the take-off path up to the maximum take-off altitude or 7,000 feet, whichever is less, has been clarified to explicitly state that the altitudes cited in the requirement are density altitudes.

Proposal 4 - CS 27.75 Landing

The proposed rule would revise CS 27.75(a) to state the required flight condition in more traditional rotorcraft terminology. Included in this revision to CS 27.75(a) is the requirement for multi-engine helicopters to demonstrate landings with one engine inoperative and initiated from an established approach. The proposed rule would also make a minor revision in the text of sub-paragraph (a) of this paragraph by replacing the word “glide” with “autorotation”.

Proposal 5 - CS 27.79 Limiting Height-Speed Envelope

The proposed rule revises CS 27.79(a)(1) to include the words "density altitude" after "7000 feet". The proposed rule would also revise CS 27.79(a)(2) by removing the word “lesser” from the first sentence. This change reflects that current OGE weights for helicopters are not necessarily less than the maximum weight at sea-level. Additionally, in CS 27.79(b)(2), the term “greatest power” is removed and replaced with language that more clearly states the power to be used on the remaining engine(s) for multi-engine helicopters. This “minimum installed specification power” is the minimum uninstalled specification engine power after it is corrected for installation losses. The specific text in the proposed rule of the ambient conditions that define the engine power to be used during the compliance demonstration is consistent with existing advisory material and current industry practice.

Proposal 6 - CS 27.143 Controllability and Manoeuvrability

This proposed rule would revise CS 27.143(a)(2)(v) to replace the word “glide” with “autorotation”. This minor change does not affect the method of compliance but states the required flight condition in more traditional rotorcraft terminology.

This proposed rule would redesignate CS 27.143(c) sub-paragraphs (1) through (4). Sub-paragraph (4) would become sub-paragraph (1) and sub-paragraphs (1), (2), and (3) would become sub-paragraphs (i), (ii), and (iii). Sub-paragraph (c) in CS 27.143 is rewritten to more clearly state that controllability on or near the ground must be demonstrated throughout a range of speeds from zero to at least 17 knots. The current Part 27 rule could lead some applicants to conclude that only a 17-knots controllability data point must be considered. That was not the intent of the current Part 27 requirement. The most critical speed may be less than 17 knots. Additionally, the altitude requirement is clarified with the addition of the words "density altitude".

27.143(c)(2) is revised to require that controllability be determined at altitudes above 7,000 feet density altitude if take-off and landing data are scheduled above that altitude. Currently, no requirement exists to determine controllability above 7,000 feet, even though take-off and landing data may be presented above that altitude. With the advent of lighter and more powerful engines, it is not uncommon for rotorcraft to operate at altitudes that, until recently, were limited to a small number of rotorcraft performing very specialized operations. Since more rotorcraft are operating at these altitudes, safety dictates that controllability and manoeuvrability be determined above 7,000 feet.

The proposed rule would add CS 27.143(d) to require the determination of controllability for wind velocities from zero to at least 17-knots OGE at weights selected by the applicant. Operations in support of law enforcement, search and rescue, and media coverage are often performed in such a manner that the rotorcraft performance in rearward or quartering flight is important in accomplishing the mission. This new requirement in CS 27.143(d), in conjunction with the proposed OGE hover requirement of CS 27.49, would increase the level of safety by requiring additional performance information.

Proposal 7 - CS 27.173 Static Longitudinal Stability

A minor clarification change is made to sub-paragraph (a) in CS 27.173 to change "a speed" to "an airspeed". Sub-paragraph (b) would be combined with sub-paragraph (c) in CS 27.173 to allow neutral or negative static stability in limited areas of the flight envelope, if adequate compensating characteristics are present and the pilot can maintain airspeed within 5 knots of the desired trim speed during the conditions specified in CS 27.175.

The ability to maintain appropriate airspeed control during other flight conditions would be tested under CS 27.143. Neutral or negative static longitudinal stability in limited flight domains has been allowed for numerous rotorcraft under equivalent level of safety findings when adequate compensating features have been present. The satisfactory experience gained with these equivalent safety findings has provided the basis for the proposed change. Historically, these limited flight domains have been encountered at the aft limit of the weight/CG envelopes during descent, or autorotation, or climb stability demonstrations. Historically, negative longitudinal control position gradient versus airspeed has generally been no more than 2 to 3 percent of the total control travel.

Additionally, these proposals would delete the CS 27.173(c) requirement relating to the hover demonstration specified in the current CS 27.175(d). See additional discussion at CS 27.175.

<u>Proposal 8 - CS 27.175 Demonstration of Static Longitudinal Stability</u>

The proposals in sub-paragraphs (a) and (b) would decrease the speed range about the specified trim speeds to more representative values than are currently contained in the rule. A new sub-paragraph (c) would require an additional level flight demonstration point. The current sub-paragraph (c) would be redesignated as sub-paragraph (d), and the current sub-paragraph (d) containing the hover demonstration point would be deleted.

Some current requirements in 27.175 are not appropriate for the newer generation of rotorcraft. When the current regulation was written, the cruise demonstration of 0.7 V_H to 1.1 V_H typically represented approximately a 30-knots speed variation for helicopters. Now, the cruise demonstration, between the maximum and the minimum speeds (1.1 V_H and 0.7 V_H), can encompass such a large speed range that the trim point and end points actually represent completely different flight regimes rather than perturbations about a trim point in a given flight regime. For some modern helicopters with a never-exceed speed (V_{NE}) in excess of 150 knots, the speed variation for the cruise demonstration could approach 60 knots, which makes the manoeuvre difficult to perform and does not represent a normal variation about a trim point. These proposals would reduce the speed range for the cruise demonstration to ±10 knots about the specified trim point.

An additional demonstration point at a trim airspeed of V_{NE} -10 knots is proposed to maintain the data coverage over a speed range similar to that contained in the current 27.175(b).

For the demonstration in autorotation, the current requirement specifies that the rotorcraft be trimmed at speeds found necessary by the Administrator/Agency to demonstrate stability. The proposed rule would specify typically used trim speeds--

minimum rate of descent and best angle of glide airspeeds--for the stability demonstration. The conditions required to develop these airspeeds are currently stated in CS 27.67 and CS 27.71. The proposed rule would also limit the speed range for demonstration to ±10 knots from the trim points. The proposed new trim points and speed ranges may not encompass V_{NE} in autorotation as explicitly required in the current CS 27.175. The proposed trim points, however, provide data at the most likely operating conditions. Autorotation at V_{NE} is typically a transient and dynamic flight condition that often places high workload demands on the pilot due primarily to maintaining rotor speed control and the desired flight path. During these dynamic conditions of autorotation at V_{NE} that are evaluated under CS 27.143, longitudinal static stability is less important than in the more stabilized conditions as proposed.

This proposed rule would delete the hover demonstration requirements of the current CS 27.175(d). The requirement to demonstrate static longitudinal stability in a hover has been shown to be unnecessary since the proper sense and motion of controls during hover are evaluated as part of other required tests. The controllability and manoeuvrability requirements of CS 27.143(a) and (c) adequately address the safety considerations during hover flight.

Proposal 9 - CS 27.177 Static Directional Stability

This proposed rule would revise CS 27.177 to change the demonstration criteria for static directional stability. The current Part 27 rule contains general language and relies primarily on a pilot's subjective judgement that he is approaching the sideslip limit, which renders it difficult to make compliance determinations due to a lack of objective test criteria. The proposals would provide further objective criteria over which the directional stability characteristics of rotorcraft are evaluated. The proposed rule also allows for a minimal amount of negative stability around each trim point. This recognizes the characteristics exhibited by many rotorcraft that have some airflow blockage of the vertical fin or tail rotor at small sideslip angles. This minimal amount of negative stability does not materially affect the overall safety considerations of static directional stability.

Proposal 10 - CS 27.903 Engines

This proposed rule would revise CS 27.903 to add a new sub-paragraph (d) to require engine restart capability. A restart capability is a fundamental necessity for any aircraft to minimize the risk of a forced landing. A restart capability will enhance safety, even though it will not be useful in every case, such as when there is engine damage or insufficient altitude to carry out the restart procedure. A study of accident and incident data shows a large number of engine failures or flameouts. A number of these incidents resulted in successful in-flight restarts following failure due to causes such as snow and ice ingestion, fuel contamination, or fuel mismanagement. The proposed text, taken directly from the current CS 29.903(e) with a slight format change, would require an in-flight restart capability for both single-engine and multi-engine rotorcraft. It is intended that restart procedures be included in the RFM.

Proposal 11 - CS 27.1587 Performance Information

27.1587(a) would be revised to include a reference to new CS 27.49. 27.1587(a)(2)(i) and (ii) would be revised to specifically include requirements for presenting maximum safe winds for OGE operations established in the proposed CS 27.143.

Proposal 12 - Appendix B – Airworthiness Criteria for Helicopter Instrument Flight

The proposed rule would amend sub-paragraph (V)(a) to allow for a minimal amount of neutral or negative stability around trim and would replace the words "in approximately constant proportion", with "without discontinuity". This is intended to be a more objective standard that does not allow irregularity in the aircraft response to control input. Also, this is consistent with the change that is proposed in CS 27.177 of the VFR requirements that proposes more specific criteria over which to evaluate stability characteristics, but also recognizes a minimal amount of negative stability. Additionally, the proposed sub-paragraph would require that the pilot be able to maintain the desired heading without exceptional skill or alertness. Lastly, in sub-paragraph (V)(b) - the word "cycle" is replaced by the correct word, "cyclic".

This proposed rule would also revise sub-paragraphs VII(a)(1) and VII(a)(2). This revision reorganizes the sub-paragraphs to further specify the standards that must be met when considering a stability augmentation system failure.

Proposal 13 - Advisory Material

A substantial package of advisory material was developed by the ARAC Working Group at the same time as the above proposals and is contained in Appendix A of this NPA. This will be made available by the FAA by notice in the Federal Register. In due course, when the material is published in an update to FAA AC 27-1B, an NPA will be raised to adopt the changes in Book 2 of CS-27.

d) Effects on Harmonisation

Harmonisation of CS-27 with FAR Part 27 will be maintained by identical amendments to FAR Part 27 which are being proposed by the FAA concurrently with this NPA.

e) Economic Impact Evaluation Assessment

A complete economic evaluation assessment has been undertaken as part of the FAA NPRM process. In summary, the FAA has determined in conducting this assessment that the NPRM has benefits which justify its costs and that the NPRM is not a "significant regulatory action" as defined in Executive Order 12866 and is not "significant" as defined in the Department of Transportation's regulatory policies and procedures. The FAA has concluded that the industry will incur almost all of the cost expected to accrue from implementation of the proposed NPRM but that the total estimated cost is not large.

The FAA has determined that the proposed changes to 27.49, 27.143, 27.175, 27.177 and 27.903 would incur additional costs for manufacturers but that 27.25, 27.51, 27.75, 27.79, 27.1587 and Appendix B would impose no substantive costs on the manufacturers and 27.173, on static longitudinal stability, would be cost relieving to the manufacturers.

This proposed rule overall is designed to improve aviation safety. Some of the proposed changes clarify existing language and adopt existing practices while others harmonize the United States Federal Aviation Regulations with the European airworthiness standards. Other proposals would require manufacturers to update the rotorcraft performance and handling quality standards for new rotorcraft certification. One specific group of provisions, 27.143 on controllability and manoeuvrability, should have a more positive effect on aviation safety by requiring that controllability be determined at altitudes above 7,000 feet (currently, no requirements exist to determine controllability above 7,000 feet). Controllability testing is also conducted to ensure that the helicopter can hover and manoeuvre with cross winds and tail winds. The proposed 27.143 would also require manufacturers to obtain out-of-ground effect (OGE) controllability data. Obtaining these data would be beneficial and enhance safety because many helicopter operators utilize their helicopters in the low-speed, out-of ground-effect flight regime.

Based upon the low compliance cost coupled with the potential safety benefits, the FAA concludes, and EASA concurs, that the benefits of the proposed rule changes justify the costs of the proposed changes to FAR Part 27 and CS-27.

V JAA NPA Comment-Response Document

In May 2003 the JAA published NPA 27-20 for public comment. The comments received (see following Table) were not dispositioned at the time, as it was felt that it would be more efficient to await the outcome of the FAA NPRM on the same subject, and to disposition comments jointly.

While EASA retains this basic view, comments revieved by the JAA as a result of NPA 27-20 have ungone a limited review and (as far as they were accepted and are still applicable) have been incorporated into this NPA. Where no response is given, comments are being held in abeyance for future disposition along with comments received on this NPA and the associated FAA NPRM.

Paragraph	Comment	Response
27.175(d)	(1) (iv) The rotorcraft trimmed at the minimum rate of descent **airspeed** (2) (iv) The rotorcraft trimmed at the best angle-of-glide **airspeed**	Accepted and incorporated in this NPA
27.177(a)(2)	Change the current NPA text for JAR 27.177(a)(2) from "**The limit sideslip angle defined under JAR 27.351**"; and replace it with new text : "**The steady state sideslip angles resulting from compliance with JAR 27.351**";	Partially Accepted. Proposed wording is further amended and incorporated in this NPA.
27.177	Delete current NPA text on JAR 27.177(a)(4).	
AC 27.75A	Although not forming part of the proposed change under this NPA, it is noted that **AC 27.75A (5)** is entitled All-engine-out landing. "AEO" currently means All Engines Operating. "OEI" means One Engine Inoperative: both phrases are in common use. To avoid future confusion it is suggested that this section of the AC might be better entitled "AEI All Engines Inoperative".	
27.79 (b)(2)	"..engine isolation features ~~insure~~ ensure continued operation…".	Noted. Correction already made to CS-27 at initial issue.

Appendix A

Advisory Material

*(**Note** – While this AMC material is considered to be a part of this NPA, and is published for comment in accordance with EASA procedures, it is not intended to publish this material in Book 2 of CS-27 directly. In due course, the material (amended as necessary as a result of comments received in response to this NPA and separate FAA consultation), will be published in an update to FAA AC 27-1B and will then undergo a further formal consultation process in accordance with EASA procedures before adoption by reference in Book 2 of CS-27).*

Proposal 13.1

Amend AC 27.25 by the addition of:

AC 27.25A. § 27.25 (Amendment 27-XX) WEIGHT LIMITS.
a. Explanation. Amendment 27-XX adds a requirement to create weight, altitude, and temperature limitations for those rotorcraft that are not able to meet the basic requirements of 27.79 or 27.143(c). The 27.79 Height velocity diagram must be demonstrated at maximum weight or at the highest weight allowing OGE hover at a density altitude of 7,000 feet. The 27.143(c) controllability must be demonstrated at maximum weight at 7,000 feet density altitude. If either or both of these requirements can not be met, the applicant must have in place the appropriate limitations to assure that take-offs and landings are limited to those weights, altitudes, and temperatures for which satisfactory demonstration has been made. 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 take-off and landing has been established as 3,000 feet density altitude.
b. Procedures. The policy material pertaining to the procedures outlined in this section remain in effect.

Proposal 13.2

Introduce a new AC 27.49 (modified from former AC 27.73) as follows:

AC 27.49. § 27.49 (Former 27.73) (Amendment 27-XX) Perfomance at Minimum Operating Speed.

(For § 27.73 prior to Amendment 27-XX, see paragraph AC 27.73)

a. Explanation.
Amendment 27-XX adds a requirement to determine out-of-ground effect hover performance. OGE operations once reserved for special missions are now a common practice.

(1) The word "hover" applies to a helicopter that is airborne at a given altitude over a fixed geographical point regardless of wind. Pure hover is accomplished only in still air. For the purpose of this manual, the word "hover" will mean pure hover.

(2) The regulatory requirement for hover performance, ~~§ 27.73~~§ 27.49, refers to hover in-ground effect (IGE) and out-of-ground effect (OGE). ~~For some applications, such as external load operations, hover performance out-of-ground effect (OGE) is~~

~~necessary; however, it is not required by this section. Hover OGE is that condition, where an increase in height above the ground will not require additional power to hover.~~ Hover OGE is the absence of measurable ground effect. ~~It can be less than one rotor diameter at low gross weight increasing significantly at high gross weight. The lowest OGE hover height at gross weight may be approximated by placing the lowest part of the vehicle one and one-half rotor diameters above the surface.~~ Hover OGE is established when the power needed is the same at different heights above the ground.

(3) The objective of hover performance tests is to determine the power required to hover at different gross weights, ambient temperatures, and pressure altitudes. Using nondimensional power coefficients (Cp) and thrust coefficients (C_t) for normalizing and presenting test results minimizes the amount of data required to cover the helicopter's operating envelope.

(4) Hover performance tests must be conducted over a sufficient range of pressure altitudes and weights to cover the approved ranges of those variables for take-off and landing. Additional data should be acquired during cold ambient temperatures, especially at high altitudes, to account for possible Mach effects.

(5) The in-ground effect hover ceiling for which data should be obtained and subsequently presented in the flight manual should be the same height consistent with the minimum hover height demonstrated during the take-off tests. Refer to paragraph AC 27.51 for the procedure to determine this hover height.

b. Procedures.

(1) Two methods of acquiring hover performance data are the tethered and the free flight techniques. The tethered technique is accomplished by tethering the rotorcraft to the ground using a cable and load cell. The load cell and cable are attached to the ground tie-down and to the rotorcraft cargo hook. The load cell is used to measure the rotorcraft's pull on the cable. Hover heights are based on skid or wheel height above the ground. During tethered hover tests, the rotorcraft should be at light gross weight. The rotorcraft will be stabilized at a fixed power setting and rotor speed at the appropriate skid or wheel height. Once the required data are obtained, power should be varied from the minimum to the maximum allowed at various rotor RPM. This technique will produce a large C_t/C_p spread. The load cell reading is recorded for each stabilized point. The total thrust the rotor produces is equal to the rotorcraft's gross weight plus the weight of the cables and load cell plus cable tension. Care must be taken that the cable tension does not exceed the cargo hook limit or load capacity of the tie-down. For some rotorcraft, it may be necessary to ballast the rotorcraft to a heavy weight in order to record high power hover data.

(2) The pilot maintains the rotorcraft in position so that the cables and load cell are perpendicular to the ground. To ensure the cable is vertical, two outside observers, one forward of the rotorcraft and one to one side, can be used. Either hand signals or radio can be used to direct the pilot. The observers should be provided with protective equipment. Positioning can also be accomplished by attaching two accelerometers to the load cell which sense angle or movement along the longitudinal and lateral axes. Any displacement of the load cell will be reflected on instrumentation in the cockpit, and by reference to this instrumentation, the rotorcraft can be maintained in the correct position. Increased caution should be utilized as tethered hover heights are decreased because the rotorcraft may become more difficult to control precisely. The tethered hover technique is especially useful for OGE

hover performance data because the rotorcraft's internal weight is low and the cable and load cell can be jettisoned in the event of an engine failure or other emergency.

(3) To obtain consistent data, the wind velocity should be less than 3 knots as there are no accurate methods of correcting hover data for wind effects. Rotorcraft with high downwash velocities may tolerate higher wind velocities. The parameters usually recorded at each stabilized condition are:

(i) Engine torque.
(ii) Rotor speed.
(iii) Ambient temperatures.
(iv) Pressure altitude.
(v) Fuel used (or remaining).
(vi) Load cell reading.
(vii) Generator(s) load.
(viii) Wind speed and direction.

As a technique, it is recommended the rotorcraft be loaded to a center of gravity near the hook to minimize fuselage angle changes with varying powers. All tethered hover data should be verified by a limited spotcheck using the free flight technique. The free flight technique as contained in paragraph AC 27.73b(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.

(4) If there are no provisions or equipment to conduct tethered hover tests, the free flight technique is also a valid method. The disadvantage of this technique as the primary source of data acquisition is that it is very time consuming. In addition a certain element of safety is lost OGE in the event of an emergency. The rotorcraft must be reballasted to different weights to allow the maximum C_t/C_p spread. When using the free flight technique, either as a primary data source or to substantiate the tethered technique, the same considerations for wind, recorded parameters, etc., as used in the tethered technique apply. Free flight hover tests should be conducted at CG extremes to verify any CG effects. If the rotorcraft has any stability augmentation system which may influence hover performance, it must be accounted for.

(5) ~~It is extremely difficult to determine when a rotorcraft is hovering OGE at high altitudes above ground level since there is no ground reference. In a true hover, the rotorcraft will drift with the wind. Numerous techniques have been tried to allow OGE hover data acquisition at high altitudes, all of which have resulted in much data scatter. Until a method is proposed and found acceptable to the FAA/AUTHORITY, OGE hover data must be obtained at the various altitude sites where IGE hover data are obtained.~~ Comprehensive hover performance tests are typically conducted at low, intermediate (~7000 feet hd), and high altitude test sites, with prepared landing surfaces, in conjunction with take-off, landing, controllability and maneuverability testing. Alternatively, a predicted hover performance model developed for high altitude may be used if verified by limited flight testing. The extrapolation guidelines in paragraph AC 27.45 b (2) are still applicable. These higher altitude hover tests could typically be conducted in conjunction with the limited controllability tests. If the applicant is able to demonstrate to the approving airworthiness authority a method to provide a reliable hover reference, it is acceptable to conduct OGE tests without ground reference. Hover performance can usually be extrapolated up to a maximum of 4,000 feet above the highest test site altitude.

Proposal 13.3

Amend AC 27.51 by the addition of:

AC 27.51A. § 27.51 (Amendment 27-XX) Take-off.
a. Explanation. Amendment 27-XX revised the requirement to perform the test at the most critical center-of-gravity location as opposed to the most forward center-of-gravity. Although for most rotorcraft the forward c.g. is generally most critical, that is not necessarily the case for all. Additionally, the change clarifies that the test must be performed at the maximum weight requested for take-off for altitudes above sea-level. The previous requirement stated that the test be performed at a weight selected by the applicant for altitudes above sea-level. That weight was traditionally interpreted to mean the maximum requested take-off weight for that altitude and is now properly worded in the rule.
b. Procedures. The policy material pertaining to the procedures outlined in this section remain in effect.

Proposal 13.4

Amend AC 27.75 by the addition of:

AC 27.75A. § 27.75 (Amendment 27-XX) Landing.
a. Explanation. Amendment 27-XX rewords 27.75(a) by replacing the word glide with autorotation and further clarifies that the OEI approach is to be performed from an established OEI approach. The OEI approach should be made utilizing a normal helicopter approach angle of approximately 6° or some other angle determined to be acceptable to the FAA/Authority and properly referenced in the RFM.

b. Procedures. The policy material pertaining to this section remains in effect with the following changes and additions:

(1) Instrumentation/Equipment. Aircraft instrumentation may include engine and flight parameters, control positions, power lever position, and landing gear loads. A record of rotor RPM at touchdown is necessary to assure it does not exceed transient limits. Rotor RPM at touchdown may be lower than the minimum transient limit for flight, provided stress limits are not exceeded. A crash recovery team with the support of a fire engine is highly desirable.

(2) The one-engine-inoperative landing is similar in many respects to the HV tests described in paragraph AC 27.79 of this advisory circular. Most of the comments, cautions, and techniques for HV also apply here even though the typical flight conditions are less critical than limiting HV points due to a lower power level and an established rate of descent. The approach is made at a predetermined speed with one engine inoperative. The speed is reduced and the rotorcraft is flared to a conventional one-engine-inoperative landing. To show compliance, full one-engine-inoperative landing should be demonstrated from sea-level to the maximum altitude capabiliaty of the rotorcraft or 7,000 feet, whichever is less, at the maximum landing weight, without damage. For altitudes above 7,000 feet to the maximum take-off and landing altitude, compliance with this requirement is shown by demonstrating that the OEI descent rate and forward speed can be controlled to a reasonable value.

(3) Power. Power should be limited to minimum specification values on the operating engine(s). This may be accomplished by adjustment of engine topping to minimum specification values for the range of atmospheric variables to be approved. This is frequently done by installing an adjustable device in the throttle linkage with a control in the cockpit so that engine topping can be accurately adjusted for varying ambient conditions. With such a

device in the control system it becomes vitally important to check topping power prior to each test sequence.

(4) Aircraft Loading. Aft center of gravity is usually most critical because visibility constraints limit the degree to which the pilot can see the landing surface during the flare. If a weight effect is shown, a minimum of two weights should be flown at each test altitude. One weight should be the maximum weight for prevailing conditions, and the other should provide a sufficient spread to validate weight accountability.

(5) All-engine-out landing.

(i) Several procedures can be utilized to demonstrate compliance with the all-engine-out landing requirement of § 27.75(a)(1) and § 27.75(b). ~~As discussed in the explanation portion of this~~These paragraphs ~~§ 27.75(b)~~ contain~~s~~ two separate requirements. One is the ability to transition safely into autorotation after failure of the last operative engine. The second aspect of this rule requires that a landing from autorotation be possible. The second requirement is discussed below. The maneuver is entered by smoothly reducing power at an optimum autorotation airspeed at a safe height above the landing surface. Typically a full autorotation landing to touchdown is demonstrated at sea-level standard day for the maximum landing gross weight for that altitude. For altitudes above sea-level standard, a demonstration of flare effectiveness with power recovery at the maximum landing gross weight corresponding for the altitude satisfies the requirement for touchdown. The flare must reduce the autorotative descent rate and forward speed to a reasonable value. If a complete company test program has documented the all-engine-out landing capability, verification tests may be initiated at those limiting weight conditions. If not, buildup testing should be initiated at light weight. ~~If a complete company test program has documented an all-engine-out landing to the GW/ (gross weight/density ratio) limit, verification tests may be initiated at those limiting weight conditions. If not, buildup testing should be initiated at light weight.~~ This test is ordinarily conducted at mid center of gravity. ~~Typically, all altitudes may be approved with two weight limit landings-one at sea-level and one near maximum take-off and landing altitude.~~

(ii) Demonstrated compliance with this requirement is intended to show that the~~an~~ autorotative descent rate ~~can be arrested,~~and forward speed at touchdown (less than 40 KTAS is recommended) can be controlled to a reasonable value ~~(less than 40 KTAS is recommended)~~ to ensure a reasonable chance of survivability for the all engine failure condition. On multi-engine rotorcraft, rotor inertia is typically lower than for single-engine rotorcraft. RPM decays rapidly when the last engine is made inoperative. Due to this relatively low inertia level, considerable collective may be needed to prevent rotor overspeed conditions when the rotorcraft is flared for landing. Also, when testing the final maximum weight points, the pilot should anticipate a need for considerable collective pitch to control rotor overspeed during autorotative descent, particularly at high altitude~~ WAT limiting conditions~~. Some designs incorporate features which may lead to rotorcraft damage in testing this requirement (e.g., droop stop breakage or loss of directional control with skids) if landings are conducted to a full stop with the engines cut off.

(iii) The intent of this rule is to demonstrate controlled touchdown conditions and freedom from loss of control or apparent hazard to occupants when landing with all engines failed. In these cases compliance can be demonstrated by leaving throttles in the idle position and ensuring no power is delivered to the drive train. Also, computer analysis may be used in conjunction with simulated in-flight checks to give reasonable assurance that an actual safe touchdown can be accomplished. Another method may be to make a power recovery after flare effectiveness of the rotorcraft has been determined. Other methods may be considered if they lead to reasonable assurance that rate of descent ~~can be arrested~~and forward speed can be controlled to allow safe landing with no injury to occupants when landing on a prepared surface with all engines failed. Regardless of the method(s) used to comply with this requirement, careful planning and analyses are very important due to the potentially hazardous aspects of power off simulation and landing of a multi-engine rotorcraft totally without power. The all-engine-inoperative landing test is ordinarily done in conjunction with height velocity tests because ground and onboard instrumentation requirements are the same for both tests.

(6) Prior to conducting these tests, the crew should be familiar with the engine inoperative landing characteristics of the rotorcraft. The flight profile may be entered in the same manner as a straight-in practice autorotation. It is recommended that for safety reasons idle power be used if a "needle split" (no engine power to the rotor) can be achieved. In some cases, a low engine idle adjustment has been set to assure needle split is attained. In other cases a temporary detent between idle and cutoff was used on the throttle. In a third case the engine was actually shut down on sample runs to verify that the engine power being delivered was not materially influencing landing capability or landing distances. The flare is maintained as long as is reasonable to dissipate speed and build RPM Rotor RPM must stay within allowable limits. Aft center of gravity is ordinarily critical due to visibility and flarability. Following the flare, the rotorcraft is allowed to touch down in a landing attitude. Rotor RPM at touchdown should be recorded, and it must be within allowable structural limits.

<u>Proposal 13.5</u>

Amend AC 27.79 by the addition of:

AC 27.79B. § 27.79 (Amendment 27-XX) LIMITING HEIGHT-SPEED ENVELOPE.
a. Explanation. Amendment 27-XX, in addition to some minor text changes, clarifies the OEI engine power to be used (for multi-engine rotorcraft) when demonstrating the requirement. The engine power of the remaining engine is the minimum uninstalled specification power after it is corrected for installation losses. The methods of determining this power are established in the general performance paragraph of this AC.
b. Procedures. The policy material pertaining to the procedures outlined in this section remain in effect.

<u>Proposal 13.6</u>

Amend AC 27.143 by the addition of:

AC 27.143A. § 27.143 (Amendment 27-XX) Controllability and Maneuverability.
a. Explanation.
Amendment 27-XX made a minor clarification to assure that IGE controllability is demonstrated at all speeds up to 17 knots. 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, for altitudes above 7,000 feet density in which take-off and landing performance is scheduled, that the controllability of the rotorcraft be determined. The amendment also requires that OGE controllability be determined up to a speed of at least 17 knots at a weight selected by the applicant up to the maximum take-off and landing altitude of the rotorcraft.

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

(1) This regulation contains the basic controllability requirements for normal category rotorcraft. It also specifies a minimum maneuvering capability for required conditions of flight. The general requirements for control and for maneuverability are summarized in § 27.143(a) which is largely self-explanatory. The hover condition is not specifically addressed in § 27.143(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), § 27.143, include more specific flight conditions and highlight the typical areas of concern during a flight test program.

(i) Section 27.143(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 nosedown pitching of the rotorcraft and for adequate roll control. Nosedown pitching capability is needed for control of gust response and to allow necessary flight path changes in a nosedown direction. Roll control is needed for gust response and for normal maneuvering of the aircraft. In the past, 10 percent control travel 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 nosedown 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) Section 27.143(c) and (d) requires a minimum control capability for hover and take-off in winds ~~of~~ 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 take-offs for wheeled rotorcraft. ~~These requirements must be met from standard sea-level conditions to the maximum altitude capability of the rotorcraft or 7,000 feet, whichever is less.~~ On ~~rotorcraft~~ 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.

(iii) Section 27.143(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 transport Category A, demonstration of sudden complete single-engine failure is required at critical conditions throughout the flight envelope including hover, take-off, 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 take-off power where appropriate) including reasonable engine torque splits. For multi-engine Category A installations (three 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 § 27.75(b). 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 rotorcraft without transport Category A engine isolation, 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, take-off, and climb at V_Y . Maximum continuous power 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 apart 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 would 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 maximum continuous (MC) power, it does not limit engine failure testing to MC power. If a take-off power rating is authorized for hover or take-off, engine failure testing must also be accomplished for those conditions. Following power failure, rotor speed, flapping, and aircraft dynamic characteristics must stay within structurally approved limits.

(iv) Section 27.143(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 § 27.1505(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 § 27.143(b)~~, 1.1 V_{NE} at power for 0.9 V_H per § 27.175(b) or § 27.1505,~~ and § 27.175(c), and to 1.1 V_{NE} (power-off) in autorotation per § 27.143(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 Rotorcraft Flight Manual.

(3) The required controllability and maneuvering capabilities must also be considered following the failure of automatic equipment used in the control system (§ 27.672). 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 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 and/or softover malfunction should be included in the Rotorcraft Flight Manual.

b. Procedures. The policy material pertaining to this section remains in effect with the following changes and additions:

(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

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 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 1.1V_H) point obtained during stability tests required by § 27.175(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 c.g. at maximum weight with minimum power-on rotor r.p.m. 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. IGE ~~H~~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. 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 helicopter is held in the most critical position relative to wind.

Testing will normally be carried out at the power required to achieve stabilised 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 manoeuvres typical for the type and use of the rotorcraft. With rotorcraft that are operating in conditions such that the gross mass is limited by the power available, there should always be adequate tail rotor pedal available to maintain yaw control when using up to Take-off Power, but this will not be the case if the rotorcraft weight in the low speed flight envelope is limited by yaw control system capability.

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 above the trim power required to hover to allow for typical power variations that will be experienced during normal use of the rotorcraft. For example, manoeuvring 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, using 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 via 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.

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 take-off, 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 paragraph AC 27.45 b (2) are still applicable. These high altitude controllability tests could typically be conducted in conjunction with take-off, 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 high altitude tests.

(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 should be specified in the TIA. Particular attention should be given to minimum stabilized 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 § 27.903(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 nosedown 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 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 § 27.75.

Proposal 13.7

Amend AC 27.173 by the addition of:

AC 27.173A. § 27.173 (Amendment 27-XX) STATIC LONGITUDINAL STABILITY.
a. Explanation.

(1) Amendment 27-XX 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 27.173(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 which 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) The remainder of § 27.173, through reference to § 27.175, contains 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 § 27.175 by ~~requiring~~ demonstrating a stable stick position gradient through a specified speed range. ~~A defined level of instability is permitted for the hovering condition.~~ 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 alternative method of compliance is provided which 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 regulatory authorities have, under equivalent level of safety findings, certified numerous rotorcraft which have neutral or negative static longitudinal stick position stability in some flight domains. This amendment to § 27.173 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 alternative 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 § 27.175.

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 § 27.175, Demonstration of static longitudinal stability. Refer to paragraph AC 27.175 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 § 27.173(b) for most of the flight conditions and configurations tested. Extraordinary means of complying with § 27.173(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 § 27.175(a) - (d). For those flight regimes, conditions and configurations where compliance with stick position requirements of § 27.173(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.

Proposal 13.8

Amend AC 27.175 by the addition of:

AC 27.175A. § 27.175 (Amendment 27-XX) DEMONSTRATION OF STATIC LONGITUDINAL STABILITY.

a. Explanation.

Amendment 27-XX reduces the speed range for the climb and cruise demonstration points of 27.175(a) and 27.175(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 paragraph AC 27.173 (Amendment 27-XX).

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~~, and hover~~.

(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 § 27.173, which states that throttle and collective pitch must be held constant, is appropriate for administration of this rule, and the specified powers in § 27.175~~(a), (b) and (c)~~ should be considered as power established at initial trim conditions. This will result in slightly higher or lower ~~torque~~ power readings at “off trim” conditions. Collective and throttle controls are held constant when obtaining test data~~ during climb, cruise, and autorotation tests~~.

(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. Manufacturer’s recommended autorotation airspeed is ordinarily used for trim.

~~(4) Hovering is considered a flight maneuver for which the pilot repeatedly adjusts collective to maintain an approximately constant altitude above the ground. For hover stability tests, collective and throttle adjustments are made as necessary to maintain an approximately constant height above the ground. Also, a limited amount of negative longitudinal control travel is allowed with changes in speed.~~

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 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 27.175-1 plot is a typical presentation of longitudinal static stability.

(ii) Other necessary parameters include pitch attitude, pressure altitude, ambient temperature, and indicated airspeed~~ (pace vehicle or theodolite speed for hover tests). For hover tests, hover height (radar altitude if available) and surface winds should be documented. Two-way communication with a pace vehicle is highly desirable. Ground safety equipment is desirable~~.

(2) Ambient Conditions. Smooth air is necessary for stability testing. ~~Allowable wind conditions for hover stability testing are the same as those for hover controllability tests. Extrapolation is covered in paragraph AC 27.45.~~

(3) Loading. Aft center of gravity (CG) is ordinarily critical for longitudinal stability testing, although high speed flight ~~and hover~~ 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 ~~10~~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 ~~accomplished by first determining V_H (level flight speed at maximum continuous power) at the test altitude. Then reduce power to establish a level flight trimmed condition at 0.9 V_H (or 0.9 V_{NE} if lower).~~ 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) 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. ~~The collective pitch and throttle must remain fixed at the trim setting for the remainder of the test. The airspeed is then varied above and below the trim speed using the cyclic control to climb or dive slightly.~~

(iii) For climb and autorotation tests, conduct fixed collective tests through an altitude band (usually ±2,000 feet)~~, first increasing airspeed as data points are collected, then decreasing speed through the same altitude band~~. 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. Generally, it will be possible to acquire all the high speed points on one pass and the low speed points on the second.

(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: 150 (V_H), 135 (0.9V_H) trim speed, 125, 145, 115, 155, 105, and 165. 140 (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) Hover tests should be conducted by maintaining an approximately constant altitude above the ground at the hover height established for performance purposes. The test altitude above the ground may be increased to provide reasonable ground clearance during rearward flight. Groundspeed is varied using a pace vehicle, theodolite, or other velocity measuring equipment. A pace vehicle is an aid in maintaining an accurate hover height. The pilot can accurately maintain height by controlling his sight picture of the pace vehicle (level with the roof, antenna, etc.). Hover stability tests are ordinarily conducted in conjunction with hover controllability tests because instrumentation and facilities are essentially the same.

(vivii) Normally climb, cruise, and autorotation tests should be conducted at low, medium, and high altitudes. See paragraph AC 27.45 for guidance on interpolation and extrapolation. High speed stability has been critical during cold weather testing. In two recent models, V_{NE} at cold temperatures has been limited by the stability requirements of § 27.175(b). 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 during warm weather testing.

(viii) Hover stability should be verified at low altitude and, if required, at high altitude. Refer to paragraph AC 27.45b(2) for guidance on expansion and extrapolation of altitude.

NOTE: Figure AC 27.175-1 to be redrawn to delete the hover test and show representative trim speeds and the new +/- 10 kts speed range and 5 kt increments.

Proposal 13.9

Amend AC 27.177 by the addition of:

AC 27.177A. § 27.177 (Amendment 27-XX) Static Directional Stability.

a. Explanation.

Amendment 27-XX 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 consideration 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 steady state sideslip angles established by 27.351. 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.

Proposal 13.10

Amend AC 27.903 by the addition of:

AC 27.903B. §27.903 (Amendment 27-XX) ENGINES.
a. Explanation.
Amendment 27-XX Section 27.903(d) requires that any engine must have a restart capability that has been demonstrated throughout a flight envelope to be certificated for the rotorcraft.

b. Procedures
(1) The minimum envelope for the restart capability should be equal to or better than the rotorcraft take-off/landing maximum altitude and temperature limits. Compliance is usually shown by conducting actual in-flight restarts during flight tests and/or other tests in accordance with an approved test plan. Restarts should be conducted at various altitudes, ambient temperatures, and fuel temperatures using the fuel type most critical, unless the applicant can show that this parameter is not pertinent. Other concerns involve the pilot station arrangement for flight controls and engine starting controls. It should be verified that the engine start can be accomplished without jeopardizing continued safe operation of the rotorcraft. Pilot workload for a preexisting one-engine-inoperative situation, the location of the restart system controls, and the availability of a second pilot should be considered. The emergency/malfunction instruction sections of the rotorcraft flight manual (RFM) should present a detailed definition of the approved restart envelope and detailed instructions for the restart. Eligible ambient atmospheric conditions, prestart requirements (to allow for waste fuel drainage), starter duty cycle (if different from the ground start duty cycle), and prestart situation analysis should be included. The prestart situation analysis should consider the following questions:

- Should a restart be attempted in view of the cause for initial shutdown?
- Is inlet system ice ingestion a possibility?
- Is reignition of fuel in the engine nacelle a possibility?
- Is sufficient restart time available?
- Is power available?
- Is altitude sufficient to maintain terrain clearance?

The restart capability can consider windmilling of the engine as part of this restart capability; however, most rotorcraft airspeeds and the locations of the engines do not support engine windmilling up to start speeds. Only electrical power requirements were considered for restarting; however, other factors that may affect this capability are permitted to be considered. Engine restart capability following an in-flight shutdown of all engines is the primary requirement, and the means of providing this capability is left to the applicant.

(2) The restart capability should be available without any delay longer than that required to ensure a satisfactory restart, in order to minimise possible height loss following one or more engine failures. The engine certification should be checked to ensure that the Flight Manual instructions for in flight relight are consistent with any specific engine relight requirements.

Proposal 13.11

Amend AC 27.1587 by the addition of:

AC 27.1587A. § 27.1587 (Amendment 27-XX) Performance Information.
a. Explanation.
Amendment 27-XX added the requirement to include in the RFM the weight, at the maximum take-off and landing altitude, for which the rotorcraft can safely hover out-of-ground effect in winds of at least 17 knots in all azimuths. This change is in conjunction with the new demonstration requirements of 27.143(d). Additionally, this change makes clear that the in-ground effect 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 contains the performance information necessary for operation in compliance with applicable performance requirements of FAR Part 27 and applicable special conditions together with additional information and data essential for implementing pertinent operational requirements.

(2) Information on limiting height/speed envelope must be given up to at least 7,000 ft as required in Section 27.79. Giving information on limiting height/speed envelope at altitudes over 7,000 ft is desirable but not mandatory. For this information it is permissible to use a different extrapolation method, provided there is technical data to back it up.

(~~2~~3) 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, 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 minimum installed specification engine.

(iii) Wind Accountability. Wind accountability may be utilized for determining take-off and landing field lengths. This accountability may be up to 100 percent of the minimum wind component along the take-off or landing path opposite to the direction of take-off. 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 take-off 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 take-off performance due to flight through the main rotor vortex. Degradation may be determined by determining the power required to fly, by reference to a pace vehicle, at speeds of 10 knots or less.

(iv) The following list is illustrative of the information that may be provided for a normal category helicopter.

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

(B) Airspeed calibration (calibrated vs. true indicated airspeed) for level flight.

(C) 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.~~

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

(E) A statement of the maximum crosswind and downwind components that have been demonstrated as safe for operation both in and out of ground effect.~~near the ground.~~

(v) Miscellaneous Performance Data. Any performance information or data not covered in paragraphs AC 27.1587a(~~2~~3)(iv)(A) through (E) above, but considered necessary or desirable to enhance safety or to enable application of the operating regulations, should be included.

(vi) Flightcrew Notes. It is recommended that provisions be made in the "unapproved" portion of the Rotorcraft Flight Manual for inclusion of information and data of a type that is useful or desirable for operation of the rotorcraft but is not approved by FAA/AUTHORITY. (Material in this section should be consistent with material in the approved portion of the manual.)

b. Procedures. None

Proposal 13.12

Amend AC 27 Appendix B by the addition of:

AC 27 Appendix B (Amendment 27-XX) Airworthiness Guidance for Rotorcraft Instrument Flight.

a. Explanation.

Amendment 27-XX made a change to Section V Static Lateral-Directional Stability that is concurrent with the change to 27.177 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.