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Airplane Airworthiness

Transport Categories

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Civil Aeronautics Manual 4b

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Introductory Note

Civil Aeronautics Manuals are published by the Civil Aeronautics Administration to supplement and explain the Civil Air Regulations. This manual contains rules, policies, and interpretations of the Administrator of Civil Aeronautics which pertain to the current requirements of Part 4b of the Regulations of the Civil Aeronautics Board, as amended to December 31, 1953. This manual will be revised from time to time as a result of amendments to Part 4b, and as new manual material is found necessary to keep the public informed on acceptable means of showing compliance with the requirements of Part 4b.

CAA rules are issued pursuant to authority conferred upon the Administrator in the Civil Air Regulations. Such rules are mandatory and must be complied with.

CAA interpretations define or explain words and phrases of the Civil Air Regulations. Such interpretations are for the guidance of the public and will be followed by the Administration in determining compliance with the regulations.

CAA policies provide recommended methods of complying with the Civil Air Regulations. Such policies are for the guidance of the public and are not mandatory in nature.

The Administrator's rules, interpretations, and policies set forth acceptable procedures and practices for the guidance of the public in complying with the regulations. Other methods or practices which provide equivalent safety to those specified by the Administrator will also be acceptable. Any provisions which are shown to be inapplicable in a particular case may be modified upon request.

Part 4b of the Civil Air Regulations, available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., should be inserted in front of the Table of Contents and should also be consulted when using this manual. The Administrator's sections pertaining to a particular section of Part 4b are identified by consecutive dash numbers appended to the regulation section numbers. Thus, 4b.10–2 means the second section of the Administrator's sections pertaining to 4b.10 of the Civil Air Regulations.

This manual supersedes Safety Regulation Releases Nos. 246 and 252 and Supplements Nos. 1 through 10 of CAM 4b previously issued by the CAA.

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4b.10–1 (Rescinded)

4b.10–2 *Approval of automatic propeller feathering installations (CAA policies which apply to sec. 4b.10).* An automatic propeller feathering device is a design feature not specifically covered in the Civil Air Regulations. When an airplane incorporates an automatic feathering device, it will be acceptable under the provisions of section 4b.10 as providing an equivalent level of safety in showing compliance with sections 4b.115, 4b.116, 4b.120 and 4b.133 if it complies with policies prescribed in sections 4b.115–2, 4b.116–1, 4b.120–1, 4b.401–1, and 4b.700–1, and if there are no features or characteristics which make it unsafe for use on transport aircraft.

4b.16–1 *Applicant's flight test report (CAA policies which apply to sec. 4b.16).* The applicant should submit a report signed by his test pilot containing the results of flight tests which were conducted by him. It should certify that the airplane has been flown at least in all maneuvers necessary for proof of compliance with the flight requirements and it is his belief that the airplane will conform therewith. In the case of very large airplanes, this procedure may be modified as deemed necessary by the Administrator.

4b.16–2 *Pre-flight test planning (CAA policies which apply to sec. 4b.16 (a)).*

(a) *Proposed official flight test program.* Before the airplane is presented for official type certification tests, the applicant should submit to the CAA a proposed flight test program which will indicate at least the following:

(1) The area, defined by the several selections described in section 4b.100–2, which is to be covered by the terms of the type certification.

(2) All proposed tests; the order in which they are to be conducted; the purpose of each test; and for each the airplane weight, c. g. position flap setting, power to be drawn, and, where appropriate, the altitude, the trim speed(s) and the speed(s) or speed range to be investigated. Appendix A presents a list of most of the flight and operation tests generally required for the type certification program together with information relative to the airplane configuration, test procedure, and special instrumentation for each test.

(3) Since most transport airplanes undergo many changes during their life span it is well to consider this fact in setting up a flight test program. Such changes as installation of different propellers, higher powered engines, etc., can often be predicted in advance.

(4) It is often desirable to simulate operation with higher power for the determination of flying qualities and other tests, thus simplifying the problem of approving the airplane when the power change becomes effective. Data of this nature obtained during CAA flight tests may often reduce further testing during the life of the airplane.

(5) When an airplane has been type certificated in the transport category and a change is made affecting performance and/or flying qualities, the following procedure is suggested:

(i) The effect of the change on each of the flight tests in the general flight program should be noted.

(ii) Those tests which are materially influenced by the change should be listed.

(iii) A test program should be prepared embodying such of these tests as are felt to be critical or representative. This program should be forwarded to the CAA with the reasons for selecting the pertinent items. Appendix B shows representative flight programs for various types of changes and may be helpful in the preparation of the programs.

(iv) A description should be submitted of the method(s) which the applicant proposes to use in order to reduce the observed data to standard conditions.

(v) A statement should be submitted of any intention on the part of the applicant to resort to calculation in lieu of, or for the purpose of generalizing test data, together with a description of the data upon which these calculations are to be based and the methods to be used therein.

(6) Since it will require time for the CAA to determine the adequacy of this entire program, it is strongly recommended that it be submitted as early as practicable, otherwise the commencement of the testing may be delayed.

(b) *Order of testing.* The Civil Air Regulations are so worded that the results of some flight tests have a definite bearing on the conduct of other tests. For this reason careful attention should be given to the order of testing. The exact order of testing will be determined only by considering the particular airplane and test program involved. Appendix D shows a general arrangement that may be of assistance to those applicants who are not familiar with the CAA flight test procedures. Tests which are particularly important in the early stages of the program are:

(1) *Airspeed calibration.* All tests involving airspeed depend upon the calibration.

(2) *Stall speed measurement.* Most of the performance tests and flying qualities are related to the stall speed.

(3) *Minimum control speed for takeoff.* The takeoff safety speed depends upon this item.

(4) *Engine cooling.* All en route climb speeds and cowl flap settings are related to this test.

(c) *Test groupings.*

(1) *Weight and c. g.* In addition to the regulatory relation of one test to another, efficient testing requires that consideration be given to the accomplishment of as many tests on a single flight as can be accommodated successfully. The tests shown in Appendix D have been grouped under various weight and center of gravity conditions in order to facilitate the development of a flight test program.

(2) *Special instrumentation.* Similarly, consideration should be given to grouping of tests that involve special instrumentation. Examples of these are takeoff and landing tests which usually require ground equipment to record horizontal distance, height, and time. Ground calibration of the airspeed indicating system can be accomplished at the same time. The CAA possesses certain instruments which may be used for obtaining test data, such as trailing airspeed bombs, sensitive altimeters, stop watches, carbon monoxide indicators, etc., as well as photographic equipment for measuring takeoff and flight landing paths. It is therefore recommended that the matter of instrumentation be discussed with the CAA before any decision is made with regard to the detailed flight test program. A list containing those tests requiring special instrumentation is shown in Appendix E.

(3) *Data reduction.* If the overall elapsed time for the certification program is to be kept to a minimum, tests requiring considerable data reduction should be conducted as early in the program as possible. Most performance data, particularly landing and takeoff data, fall in this category.

4b.16–3 *Additional flight tests (CAA policies which apply to sec. 4b.16 (b)).*

(a) *General.* Routine CAR tests as prescribed in sections 4b.100 through 4b.743 will be conducted (in accordance with existing procedures) to determine performance, flying qualities, power plant characteristics, etc.

The official functional and reliability tests will be that portion of the tests conducted under the immediate supervision of the Type Certification Board,[1] as prescribed in (c) through (h) of this section, to show compliance with sections 4b.100 through 4b.743.

Supplementary experience consisting of other flight tests and experience with an airplane (of the same) type will be taken into consideration in establishing the extent of the official portions of the tests. This supplementary experience may be obtained by the manufacturer, military services, airlines, etc.

[1] A Type Certification Board is set up by the CAA field offices on each new type aircraft project.

Simulated tests consisting of tests on the ground or in an airplane of (like) components and equipment under conditions simulating those likely to be obtained in service will also be taken into consideration in establishing the extent of the official portion of the tests.

(b) *Functional and reliability tests.* In order to satisfactorily accomplish the objectives of section 4b.16(b) concerning additional flight tests and the extent thereof, the Administrator deems it necessary that:

(1) A comprehensive and systematic check be made in flight of the operation of all components to determine whether they "function properly," i. e., perform their intended function without introducing safety hazards.

(2) Sufficient testing and supplementary experience under actual, or a combination of simulated and actual experience, be obtained and evaluated to give reasonable assurance that the airplane is "reliable," i. e., should continue to function properly in service. (In order to obtain wider experience, manufacturers are encouraged to cooperate with airlines or other responsible operators in operating experimental airplanes of the same type under service conditions.)

(3) Appropriate corrective action be taken when the need therefor is determined under (b) (1) and (b) (2) of this section. (The CAA is concerned only to the extent that the airplane can be operated safely under suitable inspection and maintenance procedures, but is not concerned with maintenance costs.)

(c) *Test program.* The Type Certification Board for each project will decide upon a proposed official test program at the time of the preflight meeting of the Board (prior to the routine CAR flight tests) and coordinate this with the airplane manufacturer. At the conclusion of the routine CAR tests, the T. C. Board will meet again to review the experience gained in those tests, changes made in the design and any additional supplementary experience, and to revise the proposed test program accordingly.

(d) *Planning and execution of test program.* The following points should be considered:

(1) The test program should be sufficiently well planned to enable its execution in an efficient manner without overlooking important items. It is not intended that the "paper work" be overemphasized to the detriment of the practical results, and it should be reduced to a minimum for small simple airplanes. The T. C. Board will review the design features and equipment with respect to the general objectives, and prepare a list showing:

(i) Components and systems to be checked in (d) (4) of this section,

(ii) A brief description of the operations to be performed, where these are not obvious (referencing any necessary operating instructions),

(iii) Special checks or likely critical conditions,

(iv) Estimated flight time required.

(2) Allowance may be made for the functional tests already required by the routine CAR tests. Allowance may also be made for simulated testing of new features and equipment; however, the flight test program should be planned to determine the adequacy of the simulated tests (e. g., to determine whether the actual environmental conditions of temperature,[2] vibration, etc. are covered by the simulated tests) when these may be critical, and to determine whether the installation and connected systems are satisfactory. The T. C. Board will then make a consolidated estimate of the total flight time required, allowing for overlapping, and adjust this in accordance with the "Test time" outlined in (e) of this section.

(3) The program will be arranged to permit the Flight Test Agent in charge to become thoroughly familiar with the flying qualities of the airplane, particularly those not specifically covered in the routine CAR tests.

(4) All components of the airplane should be intensively operated and studied under all operating conditions expected in service and obtainable within the time and geographic limitations of the tests. Intensive operation means repeated operation of components in various sequences and combinations likely to occur in service. Particular attention should be given to potential sources of crew error, overtaxing of crew ability and the emergency pro-

[2] This does not imply that flight tests must be conducted under the most severe outside air temperatures likely to be encountered in service. It should normally be possible to determine the effects of extreme outside temperatures on local temperatures by extrapolation or by suitable correction factors.

cedures that would be required in the event of malfunction of any component. This intensive type of testing should be conducted in all cases, but the length of time for which it is continued will depend upon the simulated and supplementary experience available for the particular type, as outlined in "Test time" in (e) of this section.

(5) Ground inspections should be made at appropriate intervals during the test program to determine whether there are any failures or incipient failures in any of the components which might be a hazard to safe flight.

(6) When design changes are made during the course of the test, or when the official test airplane differs from those on which supplementary experience is obtained, or from modified versions of the same basic airplane type, the revised or modified items should be rechecked in accordance with the above procedure, but every effort should be made to include such items in the program in such a way as to avoid unduly extending the overall test time. To this end, the Administrator may accept, in lieu of additional flight tests:

(i) Special tests of the original and revised components in which the conditions causing failure are intensified and

(ii) Simulated tests of differing components.

(e) *Test time.* It is highly desirable that functioning and reliability test programs be administered uniformly so that the program and flight time for a given project would be approximately the same regardless of which T. C. Board administered the project. This is difficult to achieve without establishing fixed arbitrary test times which would obviously be contrary to the intent of section 4b.16 (b). The following procedure which permits considerable flexibility is, therefore, established for the guidance of T. C. Boards.

(1) When supplementary experience is not taken into account and the airplane is conventional in regard to complexity and design features, the functioning and reliability test programs should be 150 hours. This time may be reduced to allow for simulated testing (see (d) (2) of this section), and for supplementary experience (see (e) (2) of this section). However it may be necessary to increase the 150 hours, if difficulties are encountered in earlier flights, or for radically new design features or in extreme cases of complexity. An example of extreme complexity would be an airplane intended for operation at 40,000 ft. altitude, with automatic dive recovery flaps, turbos, variable jet exhaust, two speed cooling fans, retractable wind screens, automatic control of engine cooling, turbos, intercoolers, jet exhausts, etc. The test program for such an airplane might require as much as 300 hours if no supplementary experience were available.

(2) When satisfactory supplementary experience is available and taken into account, the following allowances should be used as a guide and applied with judgment in reducing the official flight test time. However, in any case, the official program should provide sufficient time to accomplish the objective of (b) (1) of this section in accordance with the items listed in (d) (3) and (d) (4) of this section.

(i) *For intensive experience.* When the allowance is based on the total time of any one airplane in airline crew training and similar intensive operations, two hours of such operation may be considered equivalent to one hour of official testing.

(ii) *For miscellaneous experience.* When the allowance is based on the total time of any one airplane, five hours of such experience may be considered equivalent to one hour of official testing.

(iii) *Reduction for supplementary experience.* Whenever a reduction of official test time is desired on the basis of supplementary experience, such experience should be adequately recorded and submitted to the T. C. Board as described in (f) of this section.

(f) *Reports and records.*

(1) A log should be kept of all flight tests, and accurate and complete records kept of the inspections made and of all defects, difficulties, and unusual characteristics and sources of crew error discovered during the tests, and of the recommendations made and action taken. Items for which design changes may be required will be reported to the manufacturer and the appropriate CAA engineering division.

(2) If supplementary experience is to be taken into account, similar records of such experience should be kept and submitted to the

T. C. Board, together with a list of the differences between the airplane on which the experience was obtained and the official test airplane. When supplementary experience is obtained on a large fleet of airplanes (for example, military operations) of the same or a comparable type (see (d) (6) of this section), these records may consist of statistical summaries in lieu of complete records for each individual airplane.

(3) At the conclusion of the official tests, a summary report should be prepared by the T. C. Board and forwarded to Washington for inclusion in the Type Inspection Report.

(g) *Administration.* The CAA Flight Test Agent in charge will act as coordinator of all flight activities of the T. C. Board during the official program and the agent or an alternate designated by him will participate in all flights. He will collaborate with the manufacturers' pilots in all these activities, particularly in regard to flight plans and procedures. The manufacturers' pilots should be in command of all flights, but CAA pilots will fly the airplane at least sufficiently to accomplish item (d) (3) of this section.

(1) Other CAA personnel (e. g., representatives of other divisions and specialists) will participate in the flight tests when deemed necessary by the T. C. Board to accomplish the purposes of the tests.

(2) When supplementary experience is obtained in airline operations, a CAA Aviation Safety Agent will be assigned to follow the operations, review the operator's records, and supplement these by reports to the T. C. Board.

(h) *Test airplane.* To facilitate completion of the type certification procedure one airplane may be used for the official functioning and reliability tests while another airplane (or airplanes) is used for the routine CAR tests. In such cases the test time on at least one airplane should be sufficient to accomplish the objective of (b) (2) of this section.

(i) *Modified types.* The procedure outlined in (h) applies to new type designs. When a design employs components identical to those used in previous designs, credit may be given for the supplementary experience available for such components. When a design is modified (for example, several versions of the same basic type with different engines, propellers, etc.), the modified features and components should be treated in accordance with (d) (6) of this section.

4b.18–1 *Approval of aircraft materials, parts, processes and appliances (CAA rules which apply to sec. 4b.18).* Aircraft materials, parts, processes and appliances made the subject of Technical Standard Orders shall be approved upon the basis and in the manner prescribed in Part 514 [3] of the Regulations of the Administrator, "Technical Standard Orders—C Series—Aircraft Components."

4b.18–2 *Application of Technical Standard Orders—C Series (CAA policies which apply to sec. 4b.18).*

(a) *Purpose of Technical Standard Orders.* Technical Standard Orders are a means by which the Administrator adopts and publishes the specifications for which authority is provided in section 4b.18 (a) of this chapter.

(b) *Applicability of Technical Standard Order Requirements.*

(1) The applicability of and effective dates for TSO'd items are set forth in each TSO.

(2) Each Technical Standard Order sets forth the conditions under which materials, parts, processes and appliances approved by the Administrator prior to establishment of an applicable TSO, may continue to be used in aircraft.

(3) The establishment of a Technical Standard Order for any product does not preclude the possibility of establishing the acceptability of a similar product as part of an aircraft, engine or propeller, under the type certification or modification procedures, if there is established a level of safety equivalent to that provided in the Civil Air Regulations as implemented by the appropriate Technical Standard Order and the product is identified as a part of the airplane, engine or propeller.

(c) *Administration of the Technical Standard Order (TSO) System.* The principles which apply in administering the Technical Standard Orders system are as follows:

(1) Technical Standard Orders will reference performance provisions of recognizec

[3] Part 514 is available only through the Federal Register where it appeared on October 12, 1951, 16 FR 10403. Copies of individual TSO's contained therein are available upon application to the Aviation Information Staff, Civil Aeronautics Administration, Department of Commerce, Washington 25, D. C.

government specifications, or established industry specifications which have been found acceptable by the CAA. If no satisfactory specification exists, the Orders will include criteria prepared by the Administrator. In preparing criteria of this type, the Administrator will give consideration to recommendations made by the industry.

(2) Minimum performance requirements established by the Civil Aeronautics Administration and published in Technical Standard Orders will serve as a means by which component equipment and materials intended for use in certificated aircraft will be accepted.

(3) TSO's set forth the minimum requirements for safety. Every effort will be made by the CAA to keep the requirements at the minimum levels of safety, and TSO's will not be used to set forth "desirable" standards.

(4) It will be the responsibility of the person submitting a statement of conformance to the CAA, certifying that his product meets the requirements of the TSO, to conduct the necessary tests demonstrating compliance therewith. This person will be held responsible for maintaining quality control adequate to assure that products which he guarantees to meet the requirements of a TSO do, in fact, meet these standards. The CAA will not formally approve such products as meeting the requirements of TSO's nor exercise direct inspection control over them. The statement of conformance with the provisions of a Technical Standard Order normally will be accepted by the CAA as sufficient indication that the applicable requirements have been fulfilled.

Any TSO'd item which is modified must continue to comply with the requirements of the TSO, and the person authorizing the modification will be responsible for such compliance.

(d) *Numbering of Technical Standard Orders.* Each Technical Standard Order will be assigned a designation consisting of the letters, "TSO," a series code letter "C", indicating aircraft materials, parts, processes, or appliances and a serial number to be assigned in sequence for each of the TSO's issued in the "C" series, e. g., TSO-C-1, "Smoke Detectors." Revisions are indicated by the addition of letters a, b, c, etc., after the number.

4b.100-1 *Procedure for demonstrating compliance with the flight requirements (CAA policies which apply to sec. 4b.100 (a)).*

(a) *Responsibility.* The burden of showing or implementing compliance with the requirements for an airworthiness or a type certificate rests with the applicant. The applicant should at his own expense and risk, conduct such official flight tests as determined by the CAA to demonstrate compliance with the minimum requirements. During the type inspection the applicant should make available the airplane for that purpose as well as all of the personnel and equipment necessary to obtain the required data.

(b) *Tolerances permitted for flight tests.*

(1) *General.* The tolerances in (b) (2) of this section are the allowable deviation from specified flight conditions for a particular test. They are not allowable tolerances on specific requirements, nor are they to be considered as allowable inaccuracy of measurement or of the method of determination. As an example, when demonstrating stability with specified trim speed of 1.4 V_{s_1}, the trim speed may be 1.4 $V_{s_1} \pm 3$ m. p. h. or 3 percent; however, no positive tolerance is permitted when demonstrating the minimum prescribed trim speed of 1.4 V_{s_1}.

(i) Where variation in the parameter on which a tolerance is allowed will have an appreciable effect on the test, the result should be corrected to the standard value of the parameter; otherwise, no correction is necessary. The applicant may adhere to closer tolerances if he so desires.

(ii) The following list indicates the cases in which correction for tolerances should be made:

Test	Weight	C. G.	Air speed	Power	Wind
Air speed calibration					
Stall speeds	X				
All climbs	X			X	
Landings	X		X		X
Takeoff	X		X	X	X
Accelerate	X		X	X	X
Decelerate	X		X		X
Stability and control.					
Minimum control speed.				X	

(2) *Individual tolerances.* The following are general tolerances from specified values permitted during CAA testing. These tolerances apply unless, for a particular test, other tolerances are set forth in the testing procedure. These tolerances are plus or minus variations unless otherwise noted in the particular test:

Item	*Tolerance*
Weight	+5%−10%
Critical items affected by weight	+5%−1%
C. G.	7% total travel
Air speed	3 m. p. h. or ±3% whichever is greater
Power	5%
Wind (takeoff and landing tests)	As low as possible but not to exceed approximately 12% V_{s_1} or 12 m. p. h. whichever is lower, along the runway—measured at a height of 6 feet above the runway surface.

(c) *Type Inspection Report.*

(1) All information and data obtained as a result of the type inspection investigation and tests should be reported in Form ACA 283–4b, Type Inspection Report.

(2) Upon completion of the type inspection, the applicant should prepare the information necessary to show compliance with the requirements. This material together with the Airplane Flight Manual required by section 4b.740 should be completed as promptly as possible and forwarded to the CAA.

4b.100–2 *Selection of weight, altitudes, speeds and wing flap positions (CAA policies which apply to sec. 4b.100 (b)).* Before starting official flight tests, certain data should be obtained by the applicant in order that the options prescribed in (a) through (e) of this section can be executed:

(a) *The selection of the range of weight and altitude to be covered by the flight testing required for certification.* This selection should be based upon the extent to which the applicant for certification is concerned with the operating limitations which will be imposed upon the airplane. If the applicant is not concerned with this point, he may elect to conduct only the flight tests required to demonstrate compliance with the minimum performance requirements contained in section 4b.110 together with those required to demonstrate compliance with the flying qualities and other requirements specified in sections 4b.130 through 4b.190. If it is practicable to limit the operation of the airplane by a scheduled air carrier to sea level airports containing runways of ample length and to terrain altitude not in excess of 4,000 feet, this procedure appears satisfactory. It should be noted that this case could apply to a seaplane in scheduled operation. If the applicant wishes to provide for the greatest possible flexibility in the matter of compliance with the operating limitations contained in section 40.70 of this subchapter, considerably more performance tests will be necessary. It may be entirely practicable, for example, for operation over routes involving appreciable differences in the altitude of airports, to take advantage of the improvement in performance which is possible by means of reducing the weight at which the airplane is operated. It may also be desirable to alter the various flap settings in order to improve the climbing performance at a given weight. In cases such as these, it will be necessary to determine by flight testing and calculation, the effect of weight, altitude, and flap setting, throughout the range of each for which it is desired to provide, upon the takeoff, landing, and climbing performance and to include this information in the CAA Approved Airplane Flight Manual. This selection will be left to the applicant since, even though he may find it difficult to anticipate the uses to which the airplane may subsequently be put, he is nevertheless in better position to forecast this than anyone else.

(b) *The selection of the weight range to be covered by the terms of the certification.* This selection is closely related to (a) of this section and should be based upon essentially the same considerations. The simplest possible selection of weights is a single maximum weight to be used both for takeoff and landing and as a basis for the operating limitations. The next simplest choice would appear to be a maximum takeoff weight and a maximum landing weight differing from takeoff weight. This choice requires the installation of fuel jettisoning equipment (when the takeoff weight exceeds the landing weight by more than 5 percent) of sufficient capacity to reduce the weight of the airplane from the maximum takeoff weight to the maximum landing weight in compliance with section 4b.437. The operating limitations may then be based upon the assumption that these two weights exist through each flight. The most flexible possible arrangement in the matter of weights is provided by selecting a range of weights for takeoff and a range for landing, and determining the performance as functions of these weights so that, in showing compliance with the operating limitations, any weight within these ranges may be selected to fit the requirements of a particular route. This selection should be left with the applicant.

(c) *The selection of the range of attitude to be covered by the terms of the certification.* This selection is also closely related to (a) of this section and is analogous in its nature to (a) of this section. The simplest possible selection is that indicated by the minimum performance requirements contained in section 4b.110, namely, sea level for the purposes of the determination of the takeoff and landing distances and certain of the rates of climb at 5,000 feet for the purpose of determining the en route rates of climb. The selection providing the greatest possible flexibility is the one in which these items of performance are determined for a range of altitude great enough to cover all anticipated routes over which the airplane may be operated.

(d) *The selection of the wing flap positions desired for certification.* Policies outlined in section 4b.111-1 will apply to this selection.

(e) *The selection of the critical speed*[4] *to be used in the determination of the take-off distance.* Policies outlined in section 4b.113-2 will apply to this selection.

Discussion of Policies Relating to Flying Qualities in Section 4b.100-3

The relation between flying qualities (controllability, stability, trim, stalling characteristics) and safety involves the level of skill and the degree of attention required on the part of the pilot to fly the airplane. It is theoretically possible to design an airplane which cannot be flown by a single pilot because, for example, he may not have enough strength, or alternatively a sufficiently delicate touch, to operate the controls or there may be so many necessary operations that he cannot perform all of them within the required time. The flight tests pertaining to flying qualities are specified in sections 4b.130 through 4b.133, sections 4b.140 through 4b.144, sections 4b.150 through 4b.158, sections 4b.160 through 4b.162 and sections 4b.170 and 4b.171. These requirements cover the more important characteristics and loading conditions which have been agreed to be critical or representative of flight regimes. If the airplane passes the tests no investigation of other loading conditions will ordinarily be required.

4b.100-3 *Flying qualities (CAA policies which apply to sec. 4b.100 (c)).*

(a) It should be possible to operate the airplane safely at all anticipated altitudes without requiring exceptional attention and skill by the pilot or appropriate crew members.

(b) If there is less than two m. p. h. difference in the forward and rearward c. g. stalling speeds, all flying qualities may be based upon the forward c. g. stalling speeds. Otherwise, the stalling speed appropriate to the c. g. position should be used.

(c) If there is reason to believe that any of the flying qualities would be affected by altitude, they should be investigated for the most adverse altitude condition expected in normal operation.

4b.105-1 *Use of ballast during flight tests (CAA policies which apply to sec. 4b.105).* Ballast should be carried during the flight tests whenever it is necessary to simulate pay load. Consideration should be given to the vertical as well as horizontal location of the ballast in cases where it may have an appreciable effect on the performance or flying qualities of the airplane. The strength of the supporting structures should be adequate to preclude their

[4] The practical effect of the selection of this speed is that it permits the applicant to define in the type certificate the limits of airplane weight and airport altitude within which the airplane may be operated by a scheduled air carrier in compliance with Part 40 of this subchapter.

failure as a result of the flight loads that may be imposed during the tests.

4b.110–1 *Engine power corrections (CAA policies which apply to sec. 4b.110).*

(a) *Engine power corrections for vapor pressure.* The following standard vapor pressures versus altitude have been established for the purpose of correcting airplane performance data in accordance with section 4b.110:

Altitude (Feet)	*Vapor Pressure* (in. hg.)
0	0.400
2000	.307
4000	.237
6000	.179
8000	.133
10000	.096
12000	.069
14000	.049
16000	.035
18000	.025
20000	.016
25000	.005

(b) *Engine power corrections for cylinder head temperatures.* Official flight tests should be discontinued whenever engine limitations are exceeded. This procedure automatically makes corrections of this type unnecessary.

(c) *Engine power corrections for fuel flow.* Official flight tests should not be conducted when the metering characteristics of the carburetor are outside the range of acceptable tolerances. This procedure automatically makes corrections for fuel-air mixture ratio in performance evaluation unnecessary.

4b.111–1 *Selection of the wing flap positions (CAA policies which apply to sec. 4b.111).*

(a) In the selection of the wing flap positions desired for certification, the flap position indicator should show flap up, takeoff, en route, approach, and landing positions. Various items of performance are required to be determined at each of these flap positions. Section 4b.120 (d) requires that the stalling speed with the flap in the "approach" position should not exceed 110 percent of the stalling speed with the flap in the "landing" position. No plans for flight testing should be made until these positions are selected unless the applicant wishes to investigate systematically the effect of flap position upon each of several of the items of performance which should be determined at the nominal position to be selected.

(b) The selection of multiple sets of wing flap positions is permitted in order to obtain optimum performance at various airports. However, it is recommended that the approval of multiple flap position settings for any one airplane be limited to two or at the most three.[5]

(c) A reasonable number of takeoff flap settings in excess of three may be approved for operation under Civil Air Regulations, Parts 40, 41, 42, and 43 of this subchapter if a dispatch procedure is established to provide pertinent operating limitations for the particular takeoff involved.

4b.112–1 *Procedure for determining stalling speeds (CAA policies which apply to sec. 4b.112 (c)).*

(a) Since all performance requirements are based upon some function of the stalling speeds, accurate measuring methods and careful piloting technique should be employed during the tests required for the determination of these speeds. The essential items to be considered when conducting tests to determine the stalling speeds are as follows:

(1) The airspeed system should have the same characteristics as outlined in section 4b.612–1 (a) (2). Preferably, an independent test airspeed system should be employed in measuring the stalling speeds such as a shielded or swivel impact pressure sensing head used in conjunction with a trailing static bomb. The airspeed system lag should be a minimum with the impact and static systems volumetrically balanced to eliminate the error associated with changing ambient pressure. The applicant may also determine and apply the lag correction associated with changing airspeed (deceleration) to the instantaneous value of the airspeed at which the airplane is declared to be stalled by the pilot.

(2) If the stalling speed tests are to be

[5] The reason for recommending a limited number of flap settings is due to the increasing complexity of T-category operation with the increasing number of variables such as power ratings, takeoff flap settings and associated climb speeds, temperature accountability, etc., which are contained in the Airplane Flight Manual. Each additional set of flap positions approved increases the complexity with which the performance information in the Airplane Flight Manual can be evaluated to provide the proper level of safety, particularly in the takeoff flight stage.

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conducted with the propellers delivering zero thrust, some dependable instrument by means of which zero thrust condition can be ascertained should be available in flight. The general practice of establishing zero thrust r. p. m. by calculation is acceptable.

(3) An accurate method for determining the fuel quantity should be established for the purpose of ascertaining the airplane's gross weight and c. g. position at the time of each stall.

(4) Test instrumentation should consist of the usual sensitive indicators, especially sensitive tachometers, in order to be able to maintain r. p. m. which results in zero thrust. The speed-time history during the stall should be recorded photographically. A means (such as a signal light) should be provided so that the pilot's indication of the stall can be registered on the photo-recorder.

(b) The test methods required in the options that follow (see also fig. 1, p. 66), are for the purpose of determining accurately the stalling speed used to calculate the pertinent performance climb requirements. The center of gravity positions for the stalling speed tests will vary with the option of the applicant as follows:

(1) *Climb requirement based on stalling speed at the most forward c. g. position desired for certification.* Under this option, the applicant should measure stalling speeds at the maximum forward c. g. position for certification at the maximum landing weight. However, in some cases where the forward c. g. limit is variable with weight, this would require that stalling speed tests be conducted at a weight and c. g. position outside of the approved structural limit. In lieu of this, and if the applicant so desires, he may measure the stalling speeds at the maximum forward c. g. position for maximum landing weight and also at the maximum forward c. g. position desired for certification and its associated weight.

(2) *Climb requirement based on stalling speed varying with c. g. position.* If this option is elected, the applicant should conduct a sufficient number of tests to adequately establish the variation of stalling speed with center of gravity position. In any case the stalling speed should be measured at the maximum forward c. g. position desired for certification and at the most rearward c. g. position desired for the purpose of varying the climb requirement with c. g. position.

(c) The deceleration rate actually utilized in each test may be obtained from the velocity-time history provided by photo-recorder data. The rate of deceleration determined from such data should not necessarily be related to the designated stall point but should, instead, be representative of the rate at which the airplane approached the stalled condition.

(d) *Configurations.* The stalling speeds should be demonstrated in the configurations shown in (1) and (2).

(1) *Configurations for demonstrating stalling speed V_{s_0}, section 4b.112 (a).*

Weight—maximum landing or maximum weight at required c. g. position.
C. G. position—as required in (b) of this section.
Wing flaps—landing position.
Landing gear—extended.
Engines—idling or not more than sufficient power for zero thrust at a speed not greater than 110 percent of the stall speed.
Cropeller controls—normal takeoff pitch.
Towl flaps—closed.
Prim speed—1.4 V_{s_0}.

(2) *Configuration for demonstrating stalling speeds V_{s_1}, section 4b.112 (b).*

Weight—maximum landing or maximum weight at required c. g. position.
C. G. position—as required in (b) of this section.
Wing flaps—en route, takeoff and approach positions.
Landing gear—retracted.
Engines—idling or not more than sufficient power for zero thrust at a speed not greater than 110 percent of the stall speed.
Propeller controls—normal takeoff pitch.
Cowl flaps—closed.
Trim speed—1.4 V_{s_1}.

(e) *Test procedure and required data.*

(1) Three representative stalls should be conducted for each flap position (en route, takeoff, approach, and landing) and at each c. g. position as required in (b) of this section

using not more than zero propeller thrust. In cases where the flap positions have not been predetermined, it is permissible to conduct tests using four or more equally spaced flap angles.

(2) The stalling speed tests should be conducted in accordance with the procedure outlined in section 4b.160 (c). The airspeed should be recorded at the time the airplane stalls as indicated by the pilot.

(3) Since the trim speed (1.4 V_{s_1}) and the speed at which zero thrust r. p. m. is set (not more than 1.1 V_{s_1}) are a function of the stall speed, a practice run should be made in order to determine the approximate stalling speed.

(4) The following data should be recorded for each stall:

Pressure altitude.
Ambient air temperature.
Trim speed—1.4 V_s.
1.1 V_s.
R. P. M. for zero thrust at 1.1 V_s.
R. P. M. set in test.
Actual r. p. m. at stall.
Stall speed—V_s.
Deceleration rate—$\frac{dv}{dt}$.
Wing flap position.
Landing gear position.
Weight.
C. G. position.
Torque pressure.

4b.113–1 *Downwind takeoff* (*CAA policies which apply to sec. 4b.113*). Downwind takeoff data may be approved on the following basis to provide for situations where geographic locations and terrain indicate they are desirable:

(a) *Performance*. In determining the required distances for takeoff in downwind the data should be substantiated by actual flight tests. The general methods and procedures would be comparable to those for substantiating takeoff distances in no wind. The flight tests should be conducted in tailwind components up to 150 percent of the maximum velocity for which approval is desired except that the performance tests may be simulated in zero wind as outlined below:

(1) The accelerate portions of the "takeoff" and "accelerate-stop" should be demonstrated at speeds corresponding to the zero wind plus 150 percent of the tailwind component for which approval is desired. The calculated distances for entry in the Airplane Flight Manual should also be based on 1.5 times the tailwind component, see (3).

(2) The decelerate portion of the "accelerate-stop" should be demonstrated by stopping from a speed corresponding to V_1 plus 1.5 times the tailwind velocity for which certification is desired.

(3) In determining the takeoff distances for the Airplane Flight Manual performance data, 150 percent of the effect of the reported tailwind component should be taken into account. (See sec. 4b.740–1 (d) (2) (x).)

This may in some cases, permit calculating the required distances without further tests providing sufficiently high speed takeoffs and decelerations were made in the original type tests. However, except in the circumstances outlined in (d), actual takeoffs should be made under the conditions outlined in (b) to check the flight and ground handling characteristics.

(b) *Controllability*. Takeoffs should be made in steady downwind velocities equal to 1.5 times the maximum velocity for which approval is granted to check the controllability at the higher ground speeds with correspondingly reduced aerodynamic control forces, dynamic balance of landing gear, nose gear shimmy or vibration, etc.

(c) *Brakes*. At present it is believed that the existing brake capacity requirements are sufficient to cover takeoffs in downwind velocities of 10 m. p. h. measured at 50′ height. However, in wind velocities above 10 m. p. h. and in unusual cases or special types of operation additional tests or substantiation of the adequacy of the brakes may be necessary.

(d) *Tolerances*.

(1) With regard to performance tests outlined in (a), approval may be given for calculated takeoff distances for reported tailwind velocities up to 10 m. p. h. measured at 50′ height without camera tests additional to those required for approval of the no wind data.

(2) With regard to controllability tests outlined in (b), approval may be given for reported downwind velocities up to 10 m. p. h. measured at 50′ height without additional flight tests.

Discussion of Policies Relating to Determination of the Takeoff Field Length in Section 4b.113–2

The flight path specified in section 4b.113–2 (a) necessarily involves consideration of the level of skill of the pilot who happens to be flying the airplane at the time. The conditions under which this flight path is established provides for a reasonable level of skill by requiring certain minimum speeds which should be attained, as well as a sequence and timing in which it is assumed various configuration adjustments are made to the airplane, each of which have a measurable effect upon the resulting dimensions. The takeoff field length involves the determination of the distances traversed by the airplane for two alternative sequences of events. In the first case the airplane is accelerated to the critical engine failure speed, V_1 (see sec. 4b.114), at which speed all engines are made inoperative and the airplane decelerated to rest. In the second sequence of events the airplane is again accelerated to the same speed, but at that speed the critical engine only is made inoperative and the takeoff continued under certain specified conditions. The distance required to accelerate to the critical-engine-failure speed, V_1, is thus common to both sequences.

4b.113–2 *Determination of the takeoff field length (CAA policies which apply to sec. 4b.113).*

(a) The dimensions of a takeoff flight path should be such that, if the takeoff runway has a length equal to the greater of two possible dimensions of that flight path, an engine failure may occur at any point along the runway and the airplane be able either to stop within the length of the runway or to continue and clear all obstructions to flight until a safe landing is made.

(b) In the tests required by sections 4b.113 through 4b.116, generally one set of data at one altitude should be sufficient to determine takeoff distances for altitudes from sea level to 8,000 feet. If a greater range of airport altitudes is desired, the tests should be conducted at two or more altitudes.

Discussion of Policies Relating to Selection of the Takeoff Speeds in Section 4b.114–1

Section 4b.114 (a) specifies a speed at which the engine is assumed to fail and which may be lower than the speed at which flight is possible. The operating requirements of section 40.72 of this chapter limit the takeoff operation of the airplane to a weight such that in the event of engine failure at the critical-engine-failure speed, (V_1), the airplane can be brought to rest within the length of the runway or the takeoff continued and a height of 50 feet attained at the end of the runway. It follows that for any airplane at a particular weight there is an optimum value for this critical-engine-failure speed which results in the minimum required runway length and further, this optimum condition is obtained when the two alternative distances are equal. In the case of an airplane having a comparatively high wing loading but low power loading, and particularly in the case of airplanes with four or more engines, this optimum may be appreciably below the speed at which flight is possible.

The V_2 speed specified in section 4b.114 (b) is a minimum speed at which it is considered safe to attempt to complete the takeoff with one engine inoperative. The limitation upon the takeoff safety speed, (V_2), based upon stalling speed, involves the power-off stalling speed with 20 percent and 15 percent margins as reasonable minimums to insure against inadvertent stalling of the airplane. The difference between the two margins, based upon the number of engines installed in the airplane, is due to the fact that the application of power ordinarily reduces the stalling speed appreciably. In the case of the two-engine airplane, at least half of this reduction is eliminated by the failure of an engine. In the case of a four-engine airplane, certainly less than half and probably closer to one-quarter only of the difference is eliminated by the failure of an engine. The difference in the required factors, therefore, provides approximately the same margin over the actual stalling speed under the power conditions which are obtained after the loss of an engine no matter what the number of engines (in excess of one) may be. The applicant's selection of the two speeds specified will influence the nature of the testing required in establishing the takeoff flight path.

4b.114–1 *Selection of the takeoff speeds (CAA policies which apply to sec. 4b.114).*

(a) It should be possible to continue the takeoff acceleration after the failure of an engine at the speed, V_1, until a minimum safe flying speed has been attained. This condition should be demonstrated by test in order to determine that it can be safely accomplished. Throttling an opposite engine should not be permitted during the demonstration.

(b) It should not be necessary to demonstrate a takeoff that is continued after engine failure in the case where the applicant chooses to make the critical engine failure speed not less than the takeoff safety speed. If V_1 is less than V_2, the tests should include an actual takeoff during which the critical engine is made inoperative at the minimum V_1 speed and the takeoff continued after the speed V_2 is attained.

(c) The minimum takeoff safety speed should be at least 10 percent in excess of the minimum speed at which the airplane can be safely controlled when the critical engine is suddenly made inoperative under takeoff conditions in flight. (See sec. 4b.133.)

Discussion of Policies Relating to the Determination of the Accelerate–Stop Distance in Section 4b.115–1

In establishing an accelerate and stop distance it is obvious that when the throttles are suddenly closed, a finite time will elapse before the propellers and the rotating parts of the engine are decelerated from the takeoff r. p. m. to an idling r. p. m. During this period the propellers continue to exert thrust, until a certain zero thrust r. p. m. is reached as a result of the deceleration. For this reason the speed of the airplane continues to increase beyond that speed which exists at the moment the throttles are closed before it begins to decrease again. The period of time covered by the deceleration of the engine r. p. m. is also a very critical period for the application of brakes since there usually results a change in trim of the airplane which may necessarily require certain adjustments in the position of the controls.

4b.115–1 *Determination of the accelerate-stop distance (CAA policies which apply to sec. 4b.115).*

(a) In order to establish a representative dimension for the distance that would be required in the event of an actual failure of an engine during takeoff and the election of the pilot to stay on the ground, a sufficient number of runs should be conducted starting from rest and ending at rest to determine the transition distance for piecing together the acceleration and deceleration portion of the runs. In determining this distance, the wing flaps should be in the takeoff position at least until the engines have been made inoperative, but they may thereafter be altered to aid the deceleration if it is demonstrated by the applicant that this may be done with reasonable ease and safety. The accelerate–stop tests should be demonstrated in accordance with the following provisions: These tests are predicated on the assumption that the airplane is not equipped with reverse pitch or automatic feathering propellers.[6]

(1) Accelerate and stop runs should be conducted at two weights and at one altitude, and one deceleration run to demonstrate braking capacity and deceleration characteristics associated with the maximum altitude at which it is desired to certificate the airplane. Altitude conditions should be simulated by adjusting power and air speed. At least one representative run should be made for each of three engine failure speeds at each weight. If more than one flap setting is to be used for takeoff, additional tests should be conducted to cover the flap range. (See sec. 4b.118–1 (d) (2).)

(2) If tests are not made at the maximum airport altitude, one landing or deceleration run should be made at an optional altitude for the purpose of demonstrating braking capacity and deceleration characteristics at maximum airport altitude and corresponding takeoff gross weight with the airplane at this maximum takeoff weight. The true ground speed at the start of the deceleration should correspond to that speed which would be experienced at the maximum airport altitude and weight. Discretion should be used in this test to assure remaining within safe structural and operational limits of the airplane.

(3) The accelerations may be made during takeoffs and the decelerations during landings at the takeoff configuration, providing a minimum of one acceleration and stop run is conducted at the maximum takeoff weight to determine the transition distance.

(4) Instrumentation should include means to record the airplane path relative to the runway against time in a manner to determine the horizontal distance-time history and a means should be provided to measure the wind velocity and direction, pressure altitude, engine r. p. m., manifold and/or torque pressure.

(i) The wind velocity should be measured adjacent to the runway at the height of 6 feet above the runway surface for test purposes. If wind effect on runway lengths is shown in the Airplane Flight Manual (see sec. 4b.740–1 (d) (2) (x)), the manual data should be based on reported wind velocities for a 50-foot tower height. Figure 2 (p. 67) should be used to calculate the wind velocity at the 50-foot height from the wind velocity measured at the 6-foot height.

(5) A special tolerance of not greater than ±2 percent of the maximum takeoff weight is allowed for the accelerate-stop distance tests.

(b) *Configuration.* The accelerate-stop tests should be conducted in the configuration that follows:

Weight—maximum takeoff and one lower.
C. G. position—most forward. (Most aft for reverse thrust decelerations.)
Wing flaps—takeoff position.
Landing gear—extended.
Operating engines—during acceleration, all engines operating at full takeoff power and r. p. m.; cowl flaps set in takeoff position (see sec. 4b.118–1 (d) (1)).
Inoperative engines—during deceleration, throttles closed; propellers windmilling in takeoff pitch (except for failed engine with automatic feathering, see sec. 4b.115–2); cowl flaps set in takeoff position (see sec. 4b.118–1 (d) (1)).

(c) *Test procedure and required data.*

(1) The airplane should be accelerated from full stop to each of three speeds up to V_1, the highest value of which should correspond to at least the maximum value desired for certification. The throttles should be closed at this speed and the airplane brought to a complete stop with the inoperative propellers windmilling (except when an auto-feathering device is installed).

(2) The airplane path relative to the runway should be recorded against time in a manner to determine the horizontal distance-time history.

(3) The following data should be recorded:
Pressure altitude.
Ambient air temperature.
Airplane gross weight.
R. P. M. (obtained during acceleration and deceleration).
Manifold pressure.
Torque pressure.
Carburetor air temperature.
Mixture setting.
Cowl flap position.
Wing flap position.

[6] See section 4b.115–2 for policies covering automatic feathering propellers.

Time, distance, and airspeed at engine cut.

Slope of field.

Direction of run.

(4) In addition, humidity, wind direction, and wind velocity should be recorded adjacent to the runway at a height of 6 feet above the runway surface.

4b.115–2 *Approval of automatic propeller feathering installations for use in establishing accelerate–stop distance (CAA policies which apply to sec. 4b.115).* The accelerate-stop distance should be determined with the automatic propeller feathering installation feathering the propeller of the critical engine and with the other throttles closed at the instant of attainment of V_1. (See secs. 4b.10–2, 4b.401–1, 4b.700–1, and Civil Air Regulations Part 4b Interpretation No. 1.)

4b.116–1 *Approval of automatic propeller feathering installations for use in establishing the takeoff path (CAA policies which apply to sec. 4b.116).* The takeoff path may be modified by permitting a feathered propeller instead of windmilling after the necessary time interval has elapsed from the instant of engine failure to complete feathering of the propeller. If it can be shown that the net work produced by the feathering propeller from the instant of engine failure to completion of feathering under all types of engine failure is positive using a datum based on feathered propeller drag, then it is permissible to assume that the propeller of the failed engine is in the feathered drag condition from the instant of attainment of the takeoff climb speed V_2. (See secs. 4b.10–2, 4b.401–1, and 4b.700–1.)

Discussion of Policies Relating to the Determination of the Takeoff Path in Section 4b.116–2

The takeoff path elements in section 4b.116 are intended to reflect, as closely as possible, the probable order in which a pilot would make changes to the airplane configuration in the actual case of an engine failure. They are conservative in their nature in an effort to simplify the testing required to establish the flight path. For example, it is assumed that the pilot will initiate gear retraction at the takeoff safety speed, V_2, immediately after the wheels leave the ground but that climbing performance does not increase during the retraction period over that with the gear fully extended. In the case of nonautomatic propeller feathering systems it is assumed that the pilot would not initiate propeller feathering, if an engine fails during the ground run, prior to attaining a height of 50 feet, and further that the climb performance of the airplane remains the same as with the propeller windmilling until the propeller feathering cycle is completed. However, in the case of an airplane with a slow retracting gear, propeller feathering may be started at the 50-foot height prior to the completion of the gear retraction as noted in section 4b.116 (c). It is also assumed that the cowl flaps on the inoperative engine will be closed when the airplane enters the third takeoff climb segment with the gear retracted and propeller feathered.

4b.116–2 *Determination of the takeoff path (CAA policies which apply to sec. 4b.116).*

(a) The recommended procedure for obtaining the takeoff path is to determine the ground and climb portions separately and piece the corrected data together. The takeoff flight path should be demonstrated in accordance with the following provisions:

(1) Three accelerations should be made during which the airplane is accelerated from a complete stop using all engines to speeds bracketing speed V_1 at which speed the critical engine fuel mixture is cut and the acceleration continued to speed V_2 with the inoperative engine propeller windmilling [7] in the takeoff pitch setting. If V_1 is less than V_2, a takeoff should be made on one of the above runs when the critical engine is failed at the lowest V_1 speed.

[7] When a satisfactory fully automatic propeller feathering device is installed on the airplane, advantage of such a device may be used in showing compliance with this section. See section 4b.116-1 for reference to policies covering automatic propeller feathering systems.

(2) The takeoff flap setting should be maintained throughout the takeoff flight path. If more than one flap setting is to be used for takeoff, additional tests should be included to cover the flap range (see sec. 4b.118–1 (d) (2)).

(3) See section 4b.115–1 (a) (4) for instrumentation requirements.

(4) A special tolerance of not greater than ±2 percent of the maximum takeoff weight is allowable for the ground portion of the accelerate distance.

(c) *General test program.*

(1) *Accelerate to takeoff safety speed, V_2 section 4b.116 (a).*

(i) *Configuration.* These tests should be conducted in the configuration that follows:

Weight—maximum takeoff and one lower.
C. G. position—most forward.
Wing flaps—takeoff position.
Landing gear—extended.
Operating engine(s)—takeoff r. p. m. and manifold pressure, cowl flaps in takeoff position (see sec. 4b.118–1 (d) (1)).
Critical inoperative engine—fuel mixture cut on engine most critical performancewise (see sec. 4b.118–1 (e)(2)), propeller windmilling in takeoff pitch (feathered if automatic feathering device is installed) and cowl flaps in takeoff position (see sec. 4b.118–1 (d) (1)).

(ii) *Test procedure and required data.* The airplane should be accelerated from a complete stop to the V_1 speed with all engines operating. The critical engine fuel mixture should be cut at the V_1 speed and the acceleration should be continued until V_2 speed is reached with the propeller of the inoperative engine windmilling in the takeoff pitch. The airplane's path relative to the runway should be recorded against time in a manner to determine the horizontal distance-time history. In addition the following data should be recorded:

Pressure altitude.
Ambient air temperature.
Airplane gross weight.
R. P. M.
Manifold pressure.
Torque pressure.
Mixture setting.
Cowl flap position.
Wing flap position.
Time, distance, and speed at engine cut.
Time, distance, and speed when V_2 is reached.
Slope of field.
Direction of run.

In addition, humidity, wind direction, and wind velocity should be recorded adjacent to the runway at a height of 6 feet above the runway surface.

(2) *Initial takeoff flight path segment test, section 4b.116 (b).*

(i) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff and one lower.
C. G. position—optional (see sec. 4b.118–1 (c) (2).
Wing flaps—takeoff position.
Landing gear—extended.
Operating engine(s)—takeoff r. p. m. and manifold pressure or full throttle, mixture setting for takeoff, carburetor air heat control at cold and cowl flaps in takeoff position (see sec. 4b.118–1 (d) (1)). Critical inoperative engine—throttle closed on engine most critical performancewise (see sec. 4b.118–1 (e) (2)), propeller windmilling in takeoff pitch, (feathered if automatic feathering device is installed), mixture setting at idle cut-off and cowl flaps in takeoff position (see sec. 4b.118–1(d) (1)).

(ii) *Test procedure and required data.* The airplane should be climbed at the takeoff safety speed, V_2. See section 4b.118–1 for test procedure and required data in connection with climb tests.

(3) *Second takeoff flight path climb segment test, section 4b.116 (c).*

(i) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff and one lower.
C. G. position—optional (see sec. 4b.118–1 (c) (2)).
Wing flaps—takeoff position.

Landing gear—retracted.

Operating engine(s)—takeoff r. p. m. and manifold pressure or full throttle, mixture setting for takeoff, carburetor air heat control at cold and cowl flaps in takeoff position (see sec. 4b.118–1 (d) (1)). Critical inoperative engine—throttle closed on engine most critical performance-wise (see sec. 4b.118–1 (e) (2)), propeller windmilling in takeoff pitch, (feathered if automatic feathering device is installed), mixture setting at idle cut-off and cowl flaps in takeoff position (see sec. 4b.118–1 (d) (1)).

(ii) *Test procedure and required data.* The airplane should be climbed at the takeoff safety speed, V_2. See section 4b.118–1 for test procedure and required data in connection with climb test.

(4) *Third takeoff flight path climb segment test, section 4b.116 (d).*

(i) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff and one lower.

C. G. position—optional (see sec. 4b.118–1 (c) (2)).

Wing flaps—takeoff position.

Landing gear—retracted.

Operating engine(s)—takeoff r. p. m. and manifold pressure or full throttle, mixture setting for takeoff, carburetor air heat control at cold and cowl flaps in takeoff position (see sec. 4b.118–1 (d) (1)). Critical inoperative engine—throttle closed on engine most critical performance-wise (see sec. 4b.118–1 (e) (2)), propeller feathered and cowl flaps in minimum drag position.

(ii) *Test procedure and required data.* The airplane should be climbed at the takeoff safety speed, V_2. See section 4b.118–1 for test procedure and required data in connection with climb tests.

(5) *Fourth takeoff flight path climb segment test, section 4b.116 (e).*

(i) *Configuration.* This configuration should be the same as for the third takeoff flight path climb segment except that maximum continuous power is used on the operating engine(s).

(ii) *Test procedure and required data.* The airplane should be climbed at the takeoff safety speed, V_2. See section 4b.118–1 for test procedure and required data in connection with climb tests.

Discussion of Policies Relating to Test Procedures for the Determination of Climb Performance in Section 4b.118–1

Sections 4b.119 through 4b.121 specify the airplane configurations which are considered to be representative for those operating conditions certain to be encountered in the use of the airplane. With the exception of section 4b.121, the requirements specify rates of climb which are believed to be the minimum that will guarantee the ability of the airplane to perform any necessary maneuver safely considering the possibility of an engine failure and other contingencies.

The required rates of climb specified in sections 4b.119 through 4b.120, where appropriate, are related to the stall speed squared since it has been assumed that the degree of danger associated with an emergency landing would be dependent upon the kinetic energy of the airplane. Equivalent safety dictates that excess power expressed in terms of rate of climb should be proportioned to the stall speed squared. For example, the one-engine-inoperative en route climb requirement defines a minimum rate of climb which is acceptable as evidence of the ability of the airplane to maintain altitude in case of an engine failure during cruising flight. The altitude, in standard atmospheric conditions, at which this rate of climb exists under the conditions specified becomes the basis of the operating rule specified in section 40.74 of this subchapter. Essentially similar reasoning has been used in determining climb criteria for the configurations in (a) through (c) of this section.

(a) *Climb: all engines operating, section 4b.119.*

(1) *Cruising configuration, section 4b.119 (a).* The factors which cause performance deterioration during cruising flight, such as inadequate cooling, high air temperatures, inefficient carburetion, etc., affect the airplane by reducing its available angle of climb. The climb requirement specified for this configuration will result in an approximate constant angle of climb regardless of the air speed and it is intended to insure that some climb performance will be available regardless of those conditions that may be encountered during the operation which impair performance.

(2) *Landing configuration, section 4b.119 (b).* This airplane configuration is ordinarily used in the final stages of an approach for landing, and the purpose of the specified required rate of climb is to assure that the descent may be readily arrested and that the airplane will be able to "go around" for another attempt at landing in the event conditions beyond the control of the pilot make this action necessary.

(b) *One-engine-inoperative climb, section 4b.120.*

(1) *Flaps in takeoff position: landing gear extended, section 4b.120 (a).* This requirement is specified to insure that the airplane will have a positive rate of climb during the initial stage of the takeoff for the configuration which is assumed to exist in this element.

(2) *Flaps in the takeoff position; landing gear retracted, section 4b.120 (b).* This airplane configuration is intended to be representative of the conditions which might be expected to occur in the event of an engine failure at about the time the airplane leaves the ground during takeoff. The rate of climb specified is believed to be a reasonable minimum which will insure the ability of the airplane to continue the takeoff under such circumstances. Because this segment is the more critical, it was not believed necessary to specify minimum climb requirements for the cleaner configuration which is assumed to be representative of the third or fourth takeoff flight path climb segments. However the conduct of climb tests for the latter two configurations is necessary for the determination of the takeoff path required in section 4b.116.

(3) *Flaps in en route position, section 4b.120 (c).* See the second paragraph under "Discussion of policies relating to test procedures for the determination of climb performance in section 4b.118–1."

(4) *Flaps in approach position, section 4b.120 (d).* This airplane configuration is intended to represent conditions under which a pilot would attempt to "go around" after an approach in which the engine became inoperative and section 4b.120 (d) is intended to insure that the airplane will have the performance necessary to accomplish this maneuver.

(c) *Two-engine-inoperative climb, section 4b.121.* The probability of two engines failing in a single flight is considered remote and therefore it is not believed reasonable to specify a climb requirement which would have to be met for this configuration. Climb tests should be demonstrated in this configuration for the purpose of obtaining the data necessary to be shown in the Airplane Flight Manual.

4b.118–1 *Test procedures for the determination of climb performance (CAA policies which apply to sec. 4b.118).* The test conditions and methods in (a) through (i) of this section assume that the flight test data do not exhibit excessive scatter in points and that if such scatter makes the accuracy of the climb slopes questionable, additional tests and/or the applicants' previous flight test data for the particular configuration involved should be available. The following methods are also based upon consistent flight test data that can be properly correlated, and the use of previous acceptable test and correction methods. All new tests and correction methods will be judged upon their own merits. Polar curve or other equivalent methods are acceptable. The number of climb tests recommended for each case in (a) and (b) of this section represents a minimum, and in certain instances it is possible that more tests may be necessary.

(a) *For all takeoff path segments, landing and approach climb.* If it is desired to show that the required climb is met at the highest altitude and heaviest weight to be certificated, a constant rate of climb curve with altitude should be acceptable. One good climb should be satisfactory if it is 50 ft./min., or more, in excess of the required climb at the highest altitude for which certification is desired. Three climbs (at same altitude) should be made if the R/C is less than 50 ft./min. in excess of the required climb. (No climb variation with weight or altitude.)

If it is desired to determine the rate of climb vs. altitude curve:

(1) For a sea level engine, or the critical altitude above the maximum altitude of certification (no breaks in the curve) where the altitude range is not in excess of 8,000 feet, two good climbs at each weight over the altitude range if weight spread is in excess of 10 percent but not less than 4 climbs if only one weight is used. If the altitude range is in excess of 8,000 feet, three climbs at each weight over the altitude range (6 climbs if weight range is in excess of 10 percent) should be conducted.

(2) For installations where a critical altitude is within the altitude range (one break in the curve) two climbs on one slope of the curve should be conducted at each weight and at least one climb on the other slope (6 climbs for a weight spread of 10 percent or more). If the altitude range is in excess of 8,000 feet, consideration should be given to the need for a fourth climb at each weight.

(3) For installations where two breaks in the R/C curve occur within the certification range, four climbs at each weight should be made.

(b) *For all engine en route, one-engine-inoperative en route and two-engines-inoperative en route climbs.* The regulations specify that these climbs should be determined at all altitudes of expected use and weight of certification. For each weight at least the following climbs should be conducted:

Altitude Range	SL–8,000	SL–17,000	SL–25,000
No breaks in curve (one slope)	[1] 2	[1] 3	4
One break (2 slopes)	[1] 3	4	4
Two breaks (3 slopes)	------	4	4–5
Three breaks (4 slopes)	------	5	5

[1] But not less than 4 if only one weight is used.

When an airplane is approved for more than one landing flap position, the climb requirements for the cruising and en route configurations should be based upon the stall speed with the maximum sea level landing flap position for which the airplane is eligible.

Where several climb points are available at the same test conditions the average point should be determined by averaging all consistent points not using the obviously erratic points (either high or low).

(c) *Weight and C. G. position.*

(1) The climb tests should be conducted at maximum takeoff weight for takeoff climbs and at maximum landing weight for landing climbs. Climbs should also be made at an optional lower weight for both the takeoff and landing configuration.

(2) Climbs may be made at any c. g. position except where the applicant elects to vary the stalling speed with c. g. position in which case the most critical c. g. position should be used. (See sec. 4b.112–1 (b).)

(d) *Airplane configuration.*

(1) The cowl flaps should be set in the required position prior to conducting climb tests. The position of the cowl flaps for the takeoff segments should comply with the provisions of the takeoff cooling tests of section 4b.453.

(2) If more than one wing flap setting is to be used for takeoff or landing, additional tests should be included to cover the flap range (see sec. 4b.111–1 (b)).

(e) *Engine power.*

(1) The power should be stabilized prior to conducting the climb tests. The climbs should be made at constant power or at constant throttle setting. Unless limited by engine temperature, tests should be run for at least 3 minutes at takeoff power. If limited by temperature, short duration tests of approximately 1 minute duration should be acceptable provided the stabilized climbing speed is attained by accelerating from a lower speed. Where maximum continuous power is required, climb tests should be of 5 minutes duration or not necessarily more than climbs of 2,000 feet but in any case not less than 3 minutes. If climb tests are conducted for short durations, such as takeoff climbs which are limited by an engine rating of two minutes for takeoff power, consideration should be given to the necessity of conducting an adequate number of tests in order to obtain results which are representative of the actual performance.

(2) For the one-engine-inoperative climb tests, it may be assumed that the critical inoperative engine, performancewise, is the higher powered outboard engine unless there is evidence to indicate that another engine is more critical.

(3) For all climb tests, the powerplant equipment and accessories appropriate to the specific configuration being tested should be in operation. During each test, a record should be made of such accessories in operation and of the particular engine from which power is being absorbed.

(f) The climb speeds are to be selected by the applicant, but should be consistent with the performance and cooling requirements involved. The airspeed should be stabilized prior to conducting the climb tests.

(g) The airplane's wings should be maintained in a level attitude during all takeoff climb tests with one engine inoperative.

(h) All climbs should be conducted in free air (without ground effect).

(i) In addition to the following items, the data necessary to establish the weight and c. g. position during the climb tests should be recorded.

Pressure altitude recorded at 15 second intervals.
Humidity recorded at 15 second intervals.
Air speed recorded at 15 second intervals.
R. P. M.
Manifold pressure.
Torque pressure.
Carburetor air temperature.
Mixture setting.
Throttle setting.
Cowl flap position.
Wing flap position.
Landing gear position.

4b.119–1 *Determination of all engine climb (CAA policies which apply to sec. 4b.119).*

(a) *Cruising configuration test, section 4b.119 (a).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum take-off and one lower.
C. G. position—optional (see sec. 4b.118–1 (c) (2)).
Wing flaps—optional.
Landing gear—retracted.
Engines—maximum continuous r. p. m. and manifold pressure or full throttle, mixture setting in normal position, carburetor air heat control cold and cowl flaps in CAA hot day cooling position.

(2) *Test procedure and required data.* See section 4b.118–1 for test procedure and required data in connection with climb tests.

(b) *Landing configuration test, section 4b.119 (b).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum landing and one lower.
C. G. position—optional (see sec. 4b.118–1 (c) (2)).
Wing flaps—landing position.
Landing gear—extended.
Engines—takeoff power and manifold pressure or full throttle mixture setting in normal position, carburetor air heat control cold and cowl flaps in approach position.

(2) *Test procedures and required data.* See section 4b.118–1 for test procedure and required data in connection with climb tests.

4b.120–1 *Approval of automatic propeller feathering installations for use in establishing flaps in takeoff position climb (CAA policies which apply to sec. 4b.120 (a) and (b)).* The propeller of the inoperative engine may be in the feathered condition during either or both of the landing gear extended or retracted conditions if:

(a) The propeller would be completely feathered at the beginning of these segments of the takeoff flight path, or

(b) It can be shown that the net work produced by the feathering propeller during the segment is positive using a datum based on feathered propeller drag. (See secs. 4b.10–2, 4b.401–1, and 4b.700–1.)

4b.120–2 *Determination of one engine inoperative climb (CAA policies which apply to sec. 4b.120).*

(a) *Flaps in takeoff position; landing gear extended, section 4b.120 (a).* Policies outlined in section 4b.116–2 (b) (2) will apply.

(b) *Flaps in takeoff position; landing gear retracted, section 4b.120 (b).* Policies outlined in section 4b.116–2 (b) (3) will apply.

(c) *Flaps in en route position, section 4b.120 (c).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

- Weight—maximum takeoff and one lower.
- C. G. position—optional (see sec. 4b.118–1 (c) (2)).
- Wing flaps—optional.
- Landing gear—retracted.
- Operating engine(s)—maximum continuous r. p. m. and manifold pressure or full throttle, mixture setting at normal position, carburetor air heat control at cold and cowl flaps in CAA hot day cooling position.
- Critical inoperative engine—throttle closed on engine most critical performancewise (see sec. 4b.118–1 (e) (2)), propeller feathered and cowl flaps in minimum drag position.

(2) *Test procedure and required data.* The airplane should be climbed at the en route climb speed. See section 4b.118–1 for test procedure and required data in connection with climb tests.

(d) *Flaps in approach position, section 4b.120 (d).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

- Weight—maximum landing and one lower.
- C. G. position—optional (see sec. 4b.118–1 (c) (2)).
- Wing flaps—approach position (V_{s_1} must not exceed 1.10 V_{s_0}).
- Landing gear—retracted.
- Operating engine(s)—takeoff r. p. m. and manifold pressure or full throttle, mixture setting at normal position, carburetor air heat control at cold and cowl flaps in approach position.
- Critical inoperative engine—throttle closed on engine most critical performancewise (see sec. 4b.118–1 (e) (2)), propeller feathered and cowl flaps position optional.

(2) *Test procedure and required data.* The airplane should be climbed at the approach climb speed. See section 4b.118–1 for test procedure and required data in connection with climb tests.

4b.121–1 *Determination of two engine inoperative climb (CAA policies which apply to sec. 4b.121).*

(a) *Configuration.* This test should be conducted in the configuration that follows:

- Weight—two optional weights.
- C. G. position—optional (see sec. 4b.118–1 (c) (2)).
- Wings flaps—optional.
- Landing gear—retracted.
- Operating engines—maximum continuous r. p. m. and manifold pressure or full throttle, mixture setting at normal position, carburetor air heat control at cold and cowl flaps in CAA hot day cooling position.
- Critical inoperative engines—throttles closed on outboard engine most critical performancewise (see sec. 4b.118–1 (e) (2)), and on adjacent engine, propellers feathered and cowl flaps in minimum drag position.

(b) *Test procedure and required data.* See section 4b.118–1 for test procedure and required data in connection with climb tests.

4b.122–1 *Downwind landings (CAA policies which apply to sec. 4b.122).* Downwind landing data will be approved on the following basis to provide for situations where geographic locations and terrain indicate they are desirable, as well as for use with ILS:

(a) *Performance.* In determining the required distances for landing downwind, the data should be substantiated by actual flight tests. The general methods and procedures should be comparable to those for substantiating landing distances in no wind. The flight tests should be conducted in tailwind velocities up to the maximum velocity for which approval is desired except that the performance tests may be simulated in zero wind as outlined below:

(1) Landings should be demonstrated by approaching and contacting at speeds corresponding to the zero wind speed plus 150 percent of the tailwind velocity for which approval is desired.

(2) In determining the downwind landing distances for the Airplane Flight Manual data, 150 percent of the effect of the reported tailwind velocity should be taken into account. (See sec. 4b.740–1 (d) (2) (x).) This may in some cases, permit calculating the required distances without further tests providing sufficiently high speed landings and decelerations were made in the original type tests. However, except in the cases outlined in (d), actual landings should be made under the conditions described in (b) to check the flight and ground handling characteristics.

(b) *Controllability.* Landings should be made in steady downwind velocities equal to 1.5 times the maximum velocity for which approval is desired to check the controllability at the higher ground speed with correspondingly reduced aerodynamic control forces, dynamic balance of landing gear, nose gear shimmy or vibration, etc. Also actual approaches should be demonstrated under the above wind conditions at an approach angle corresponding to the maximum ILS beam angle (3° 18′) to determine the minimum altitude on the glide path from which the airplane can be readily flared for landing.

(c) *Brakes.* At present it is believed that the existing brake capacity requirements are sufficient to cover landings in downwind velocities of 5 m. p. h. However, in wind velocities above 5 m. p. h. and in unusual cases or special types of operation, a revision to the braking system may be required. In determining the landing distances under (a), normal braking as outlined in section 4b.123 "Landplanes" should not be exceeded.

(d) *Tolerances.*

(1) With regard to performance tests outlined in section 4b.122–1 (a), approval will be given for calculated landing distances for reported tailwind velocities up to 10 m. p. h. measured at 50 feet height without camera tests additional to those required for approval of the no wind data.

(2) With regard to controllability tests outlined in section 4b.122–1 (b), approval will be given for reported downwind velocities up to 10 mph. measured at 50 feet without additional flight tests.

Discussion of Policies Relating to Determination of the Landing Distances in Section 4b.122–2

The purpose of the requirement specified in section 4b.122 is to determine a distance from a point 50 feet above the takeoff surface to land and bring the airplane to rest. This procedure is representative of the actual operating technique and may serve as the basis for the specification of a landing runway length within which a pilot of average skill may reasonably be expected to be able to land the airplane safely under the most adverse weather or other operating conditions likely to be encountered in the actual operation.

The minimum approach speed of 1.3 V_{s_0} specified in section 4b.122 (a) is intended to provide a reasonable margin above the stalling speed. The "steady gliding approach" is an approach at essentially constant indicated air speed for a sufficient length of time prior to reaching the 50-foot point to simulate a continuous approach at this speed.

Sections 4b.122 (b), (c), and (d) are concerned primarily with preventing airplane contact with the runway surface at a very high speed in order to take advantage of the greater deceleration provided by most wheel brake installations than is available from the drag of the airplane while still airborne. Flight Engineering Report No. 1, "Investigation of the Landing Distance Required by CAR 04.7503 for a Typical Airplane," covers an investigation undertaken to determine the effect of various factors which were considered in drafting section 4b.122 and indicates the critical dependence of the landing distance here defined upon the contact speed. The purposes of section 4b.122 (d) would be defeated if a distance is obtained by making contact at high speed which would require an exceptional degree of skill on the part of the pilot, or to base a distance upon exceptionally favorable conditions such as wind or the nature of the surface of the runway.

4b.122–2 *Determination of the landing distances (CAA policies which apply to sec. 4b.122).*

(a) When a particular ariplane cannot comply with that part of section 4b.122 (d) regarding exceptional degree of skill on the part of the pilot in landing from the 50-foot height with power off, compliance with the regulation should be shown by applying sufficient power during the approach to permit satisfactory landing.

(b) In the tests required by sections 4b.123 through 4b.124 generally one set of data at one altitude should be sufficient to determine the landing distances for altitudes from sea level to 8,000 feet. If a greater range of airport altitudes is desired, the tests should be conducted at two or more altitudes.

4b.123–1 *Excessive wear of brakes or tires (CAA interpretation which applies to sec. 4b.123 (b)).* "Excessive wear" is interpreted as skidding of a tire or excessive heating of the brakes which requires replacement during a series of five official test landings.

4b.123–2 *Determination of the landing distance (landplanes) (CAA policies which apply to sec. 4b.123).*

(a) The landing tests should be demonstrated in accordance with the following provisions:

(1) Landings should be made over an imaginary 50-foot obstacle at the maximum landing weight and at a lower weight at one altitude.

(2) During the landing demonstrations, the glide path should be established by the pilot as set forth in section 4b.122. The forward thrust should not be increased beyond the 50-foot obstacle. The ground roll should lie as close to a rectilinear path as possible including the airplane stop point. During each demonstration landing, the airplane should be brought to a complete stop.

(3) *Instrumentation.*

(i) Instrumentation should include a means to record the airplane's glide path relative to the ground and the ground roll against time in a manner to determine the horizontal and vertical distance-time histories.

(ii) A means should be provided to measure the wind velocity and direction, pressure altitude, and ambient air temperature. The wind measurement should be made at the height of 6 feet above the runway surface. If wind effect on runway lengths is shown in the Airplane Flight Manual (see sec. 4b.740–1 (d) (2) (x)), the manual data should be based on reported wind velocities for a 50-foot tower height. Figure 2 should be used to calculate the wind velocity at the 50-foot height from the wind velocity measured at 6 feet above the runway surface.

(iii) The ground roll distance from contact to full stop should be established by observers if it is difficult to establish the exact contact point by graphical means.

(4) A special tolerance of not greater than ± 2 percent of the maximum landing weight is allowable for the landing distance tests.

(b) *Configuration.* The landing tests should be demonstrated in the configuration that follows:

Weight—maximum landing and one lower.

C. G. position—most forward for braked landings.

Wing flaps—landing position.

Landing gear—extended.

(c) *Test procedure and required data.*

(1) Three landings should be conducted at each weight with the airplane stabilized in a glide at a calibrated air speed of not less than 1.3 V_{s_0} approximately 1,000 feet (longitudinally) prior to reaching an altitude of 50 feet. Forward thrust should not be increased beyond the 50-foot obstacle; braking should not exceed manufacturer's approved maximum brake pressure and should be applied in such a manner as not to produce excessive wear of brakes and tires as evidenced by five measured landings. If more than one flap setting is to be used for landing, additional tests should be conducted to cover the flap range. (See sec. 4b.118–1 (d) (2).)

(2) The airplane path relative to the runway should be recorded against time in a manner to determine the horizontal and vertical distance–time history. In addition, the following data should be recorded:

Pressure altitude.
Ambient air temperature.
Airplane gross weight.
R. P. M.
Manifold pressure.
Torque pressure.
Carburetor air temperature.
Mixture setting.
Cowl flap position.
Wing flap position.
Slope of field.
Direction of landing run.

(3) Humidity, wind direction, and wind velocity should be recorded adjacent to the runway at a height of 6 feet.

4b.124–1 *Determination of the landing distance (seaplanes) (CAA policies which apply to sec. 4b.124).* Policies outlined in sections 4b.122–2 and 4b.123–2 will apply.

4b.125–1 *Determination of the landing distances (skiplanes) (CAA policies which apply to sec. 4b.125).* Policies outlined in sections 4b.122–2 and 4b.123–2 will apply.

4b.130–1 *Procedure for demonstrating controllability qualities (CAA policies which apply to sec. 4b.130).* The general controllability and maneuverability qualities of the airplane should be observed and noted throughout the flight test program. The amount of force required to be exerted on the controls in conducting such maneuvers specified in section 4b.130 should also be noted.

Discussion of Policies Relating to Procedure for Demonstrating Longitudinal Control in Section 4b.131–1

Section 4b.131 (b) requires changes to be made in flap position and/or power which are likely to be encountered during an approach when it becomes necessary to go around for another attempt at landing. Its purpose is to insure that any of these changes are possible assuming that the pilot finds it necessary to devote at least one hand to the initiation of the desired operation without being overpowered by the primary airplane controls. It aims at a design such that no excessive change in trim results from the application or removal of power or the extension or retraction of wing flaps. Compilance with its terms also requires that the relation of control force to speed be such that reasonable changes in speed may be made without encountering very high control forces.

Section 4b.131 (c) is concerned with the eventuality of going around during an approach for landing in which event it is obviously desirable to be able to retract the wing flaps quickly and automatically at such a rate that there will be no loss of altitude if power is applied simultaneously with the initiation of flap retraction no altitude should be lost. The design feature involved in this requirement is the rate of flap retraction.

4b.131–1 *Procedure for demonstrating longitudinal control (CAA policies which apply to sec. 4b.131).* The flight tests specified in (a) through (h) of this section should be made in demonstrating compliance with section 4b.131. These tests may be conducted at an optional altitude (see sec. 4b.100–3 (c)). Where applicable, the following conditions should be maintained on the engines: propellers in low pitch, throttles—closed except as noted; cowl flaps—appropriate for the flight condition.

(a) *Longitudinal control recovery to 1.4 V_{s_1}, section 4b.131 (a).* The test specified by this requirement should be demonstrated with power off and also with maximum continuous power.

(1) *Configuration.* This test should be conducted in the configuration that follows:

(i) Maximum takeoff weight, flaps and landing gear retracted, c. g. position—most aft.

(ii) Maximum landing weight, flaps extended in the maximum landing position; landing gear extended, c. g. position—most aft.

(The flap extended portion of this test may be combined with tests under (g) of this section.)

(2) *Test procedure and required data.* The airplane should be trimmed at a speed of 1.4 V_{s_1}; the nose should be pitched downward starting from any speed between 1.4 V_{s_1} and V_{s_1}. The rate of increase in airspeed should be satisfactory for prompt acceleration to a speed of 1.4 V_{s_1}. The following data should be recorded:

Weight.
C. G. position.
Wing flap position.
Landing gear position.
Engines, r. p. m. and manifold pressure.
Pressure altitude.
Ambient air temperature.
Trim speed at 1.4 V_{s_1}.
Lowest speed from which pitch is satisfactory.
Altitude lost to regain speed of 1.4 V_{s_1}.

(b) *Longitudinal control, flap extension, section 4b.131 (b) (1).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum landing.
C.G. position—most forward and most aft.
Wing flaps—retracted.
Landing gear—extended.
Engines—power off.

(2) *Test procedure and required data.* The airplane should be trimmed at a speed of 1.4 V_{s_1}; the flaps should be extended to the maximum landing position as rapidly as possible. During this maneuver, it should be possible to control the airplane with one hand for a reasonable time without the necessity of changing the trim control. The following data should be recorded:

Weight.
C. G. position.
Wing flap position.
Landing gear position.
Engines, r. p. m. and manifold pressure.
Pressure altitude.
Ambient air temperature.
Trim speed at 1.4 V_{s_1}.

(c) *Longitudinal control, flap retraction, section 4b.131 (b) (2).*

(1) *Configuration.* This test should be constructed in the configuration that follows:

Weight—maximum landing.
C. G. position—most forward and most aft.
Wing flaps—maximum landing position.
Landing gear—extended.
Engines—power off.

(2) *Test procedures and required data.* The airplane should be trimmed at a speed of 1.4 V_{s_1}; the flaps should be retracted as rapidly as possible. During this maneuver, it should be possible to control the airplane with one hand for a reasonable time without the necessity of changing the trim control. The same data as are specified in (b) (2) of this section should be recorded.

(d) *Longitudinal control, flap retraction, section 4b.131 (b) (3).*

The maneuver shown in section 4b.131–1 (c) (2) should be repeated with takeoff power on all engines.

(e) *Longitudinal control, power application, section 4b.131 (b) (4).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum landing.
C. G. position—most forward and most aft.
Wings flaps.—retracted.
Landing gear—extended.
Engines—power off.

(2) *Test procedure and required data.* The airplane should be trimmed at a speeed of 1.4 V_{s_1}; takeoff power should be applied quickly without changing the airspeed. During this maneuver, it should be possible to control the airplane with one hand for a reasonable time without the necessity of changing the trim control. The same data as are specified in (b) (2) of this section should be recorded.

(f) *Longitudinal control, power application, section 4b.131 (b) (5).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum landing.
C. G. position—most forward and most aft.
Wing flaps—maximum landing position.
Landing gear—extended.
Engines—power off.

(2) *Test procedure and required data.* The airplane should be trimmed at a speed of 1.4 V_{s_1}; takeoff power should be applied quickly without changing the airspeed. During this maneuver, it should be possible to control the airplane with one hand for a reasonable time without the necessity of changing the trim control. The same data as are specified in (b)(2) of this section should be recorded.

(g) *Longitudinal control, air speed variation, section 4b.131 (b) (6).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum landing.
C. G. position—most forward
Wing flaps—maximum landing position.
Landing gear—extended.
Engines—power off.

(2) *Test procedure and required data.* The airplane should be trimmed at a speed of 1.4 V_{s_1} and it should be possible to control the airplane with one hand for a reasonable time without the necessity of changing the trim control when:

(i) The speed is reduced to 1.1 V_{s_1},

(ii) The speed is increased to 1.7 V_{s_1} or to the placard flap speed.

In addition to the data specified in (b)(2) of this section, the recorded data should also include the airspeeds at 1.1 V_{s_1} and 1.7 V_{s_1} (or V_{FE} whichever is the lesser).

(h) *Longitudinal control, flap retraction and power application, section 4b.131 (c).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum landing:
C. G. position—most forward and most aft.
Wing flaps—maximum landing position.
Landing gear—extended.
Engines—power noted.

(2) *Test procedure and required data.* The airplane should be maintained in a steady horizontal flight at a speed of 1.1 V_{s_1}; the flaps should be retracted from the maximum landing position with simultaneous application of not more than maximum continuous power. During this maneuver, it should be possible to prevent a loss of altitude without the use of exceptional piloting skill. The following data should be recorded:

Weight.
C. G. position.
Wing flap position.
Landing gear position.
Engines, r. p. m. and manifold pressure before and after tests.
Pressure altitude.
Ambient air temperature.
Airspeed at 1.1 V_{s_1}.

4b.132–1 *Procedure for demonstrating directional and lateral control (CAA policies which apply to sec. 4b.132).*

(a) When conducting directional and lateral control tests, the airplane should contain appropriate instrumentation in order to obtain the following data:

(1) *Sections 4b.132 (a) and 4b.132 (b).* Instrumentation to indicate airplane heading angle and rudder force.

(2) *Sections 4b.132 (c) and 4b.132 (d).* Instrumentation to measure bank angle.

(b) *General test program.*

(1) *Directional control; general, section 4b.132 (a).*

(i) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum landing.
C. G. position—most aft.
Wing flaps—approach position.
Landing gear—retracted.

Cowl flaps—appropriate for flight condition.
Operating engine(s)—power to maintain level flight at 1.4 V_{s_1} but more than maximum continuous power.
Critical inoperative engine—propeller feathered on engine most critical for controllability.

(ii) *Test procedure and required data.* The airplane should be trimmed as indicated above at any optional altitude (see sec. 4b.100–3 (c)). Reasonable sudden changes in heading to the left and right, using ailerons to maintain approximate level flight, should be made demonstrating a change of 15°, or the angle at which a dangerous condition is encountered, or at which 180 lbs. rudder force is required. The airplane should be satisfactorily controllable during this maneuver. The following data should be recorded:

Weight.
C. G. position.
Wing flap position.
Landing gear position.
Operating engine(s), r. p. m. and manifold pressure.
Position of critical inoperative engine and its propeller.
Pressure altitude.
Ambient air temperature.
Trim speed at 1.4 V_{s_1}.
Rudder force at maximum deflection.

(2) *Directional control; four or more engines, section 4b.132(b).*

(i) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum landing.
C. G. position—most forward.
Wing flaps—climb position.
Landing gear—retracted.
Operating engines—power required for level flight at 1.4 V_{s_1} but not more than maximum continuous power.
Critical inoperative engines—propellers feathered on outboard engine most critical for controllability and on adjacent engine.

(ii) *Test procedure and required data.* The test procedure shown in (b) (1) (ii) of this section should be repeated with two critical engines inoperative. In addition to the data specified in (b) (1) (ii) of this section, the position of the critical inoperative engines and the propeller configuration should also be recorded.

(3) *Lateral control; general, section 4b.132 (c).*

(i) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff.
C. G. position—most aft.
Wing flaps—climb position.
Landing gear—retracted and extended.
Operating engine(s)—maximum continuous power.
Critical inoperative engine—throttle closed on engine most critical for controllability, propeller feathered.

(ii) *Test procedure and required data.* Banked turns of 20° should be demonstrated with and against the inoperative engine from a steady climb at 1.4 V_{s_1}. The following data should be recorded:

Weight.
C. G. position.
Wing flap position.
Landing gear position.
Engine(s), r. p. m. and manifold pressure.
Position of critical inoperative engine and its propeller.
Pressure altitude.
Ambient air temperature.
Trim speed at 1.4 V_{s_1}.
Rudder force at maximum deflection.
Aileron force at maximum deflection.

(4) *Lateral control; four or more engines, section 4b.132 (d).*

(i) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum landing.
C. G. position—most forward.
Wing flaps—climb position.
Landing gear—retracted.
Operating engines—power required for level flight at 1.4 V_{s1} but not more than maximum continuous power.
Critical inoperative engines—propellers feathered on outboard engine most critical for controllability and on adjacent engine.

(ii) *Test procedure and required data.* Banked turns of 20° should be demonstrated with and against inoperative engines from steady flight at 1.4 V_{s_1}. The same data as are specified in (b) (3) (ii) of this section should be recorded.

4b.133–1 *Determination of the minimum control speed, V_{MC} (CAA policies which apply to sec. 4b.133).*

(a) When demonstrating the minimum control speed, the applicant may choose one of three basic methods dependent on the inherent characteristics of the airplane or a combination of the methods is acceptable provided that the combination chosen does not allow the aircraft to exceed any of the limiting factors specified in section 4b.133. These methods are:

(1) With wings level and 180 lbs. rudder force, or full rudder travel causing airplane to deviate from a constant heading, or airplane stall.

(2) With the wing on the engine operating side lowered 5° and 180 lbs. rudder force, or full rudder travel causing airplane to deviate from a constant heading, or airplane stall.

(3) At 0° yaw and full rudder travel causing airplane to deviate from zero degree yaw, or 180 lbs. rudder force, or airplane stall.

(b) When it has been found that the aircraft is limited by the 180 lbs. rudder force in any of the methods in (a) of this section, a plot of force vs. airspeed should be made through a suitable range of speeds to substantiate the speed chosen as V_{MC}.

(c) Generally speaking, in aircraft equipped with right-hand rotation propellers, the left-hand outboard engine is the most critical when inoperative from the standpoint of control. This condition should be substantiated, however, by a comparative test with both the right and then the left outboard engines inoperative, measuring the force necessary to hold the airplane within the limits as specified in section 4b.133 at or slightly above the minimum control speed. When conducting this test it is imperative to hold all remaining factors equal so that a true comparison may be accomplished.

(d) All testing should be accomplished at the appropriate weights and powers for the range of approval desired. The minimum control speed should be determined for each takeoff flap position selected for approval if the takeoff flap is made variable with altitude.

(e) Civil Air Regulation Part 4b, Interpretation No. 1, interprets section 4b.133 (a) (8) as requiring the establishment of one engine inoperative minimum control speed with the propeller of the inoperative engine feathered providing that the airplane is equipped with an automatic feathering device acceptable to the Administrator under section 4b.10 for demonstration of compliance with the takeoff path and climb requirements of sections 4b.116 and 4b.120 (a) and (b). In such cases where the applicant chooses to demonstrate V_{MC} with the propeller feathered, the value of V_{MC} with the propeller windmilling should also be obtained and included in the Airplane Flight Manual.

(f) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff. (If stall occurs prior to reaching V_{MC}, applicant may choose to demonstrate a lower V_{MC} at a reduced weight.)

C. G.—most aft.

Wing flaps—takeoff position.

Landing gear—retracted.

Operating engine(s)—takeoff r. p. m. and manifold pressure or full throttle, cowl flaps in takeoff position.

Inoperative engine—throttle closed, propeller windmilling or any other logical position, cowl flaps in takeoff position.

(g) *Test procedure and required data.* After establishing the critical inoperative engine and the choice of method for demonstration, the tests for establishing the minimum control speed may be conducted. Using the configuration specified in section 4b.133, all engines should be adjusted for takeoff power and a series of engine cuts made by moving the mixture control of the critical engine in idle cut-off position at consecutively lower airspeeds until one of the limiting factors specified in section 4b.133 is experienced. When the minimum control speed is determined, a minimum of five demonstrations should be made to provide adequate proof that the chosen value meets the requirement. The following data should be recorded:

Pressure altitude.

Ambient air temperature.

Indicated air speed.

Engines, r. p. m. and manifold pressure.

Torque pressure.

Carburetor air temperature.

Rudder force.
Bank angle.
Gyro direction indicator.
Yaw—if method is chosen where loss of airplane's ability to maintain 0° yaw is limiting factor specified in (a) (3) of this section.

4b.140–1 *General trim qualities (CAA policies which apply to sec. 4b.140).* It should be possible to trim the airplane completely for any flight condition which is reasonable to assume will be maintained steadily for any appreciable time. Compliance for unsymmetrical power should be demonstrated with "wings level" or "zero yaw" when a yawmeter is installed as a part of the reauired equipmert.

4b.141–1 *Procedure for demonstrating lateral and directional trim (CAA policies which apply to sec. 4b.141).*

(a) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff and maximum landing.
C. G. position—most forward and most aft with greatest lateral variation in useful load. Asymmetrical fuel loading should be considered.
Wings flaps—retracted and maximum landing position.
Landing gear—retracted and extended.
Engines—power required for level flight.
Cowl flaps—appropriate for flight condition.

(b) *Test procedure and required data.* It should be possible to maintain hands-off longitudinal, lateral, and directional trim at any speed from 1.4 V_{s_1} to .9 speed at maximum continuous power in level flight or placard speed with the landing gear retracted and extended. The following data should be recorded:

Weight.
C. G. position.
Wing flap position.
Landing gear position.
Engines, r. p. m. and manifold pressure.
Pressure altitude.
Ambient air temperature.
Trim speed at 1.4 V_{s_1}.
(Additional lateral and directional trim should be demonstrated in other configurations in conjunction with tests in sec. 4b.150.)

4b.142–1 *Procedure for demonstrating longitudinal trim (CAA policies which apply to sec. 4b.142).*

(a) *Longitudinal trim during climb, section 4b.142 (a).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff.
C. G. position—most forward.
Wing flaps—retracted and takeoff position.
Landing gear—retracted.
Engines—maximum continuous power.
Cowl flaps—optional.

(2) *Test procedure and required data.* It should be possible to maintain hands-off longitudinal trim at a speed not in excess of 1.4 V_{s_1} with the wing flaps retracted and in the takeoff position. The same data specified in section 4b.141–1 (b) should be recorded.

(b) *Longitudinal trim during glide, section 4b.142 (b).*

(1) *Configuration.* This test should be conducted in the configurations that follow:

Weight—maximum landing.
C. G. position—most forward for maximum landing weight.
Wing flaps—retracted and maximum landing position.
Landing gear—extended.
Engines—power off, propellers windmilling.

(2) *Test procedure and required data.* It should be possible to maintain hands-off longitudinal trim at a speed not in excess of 1.4 V_{s_1} with the wing flaps retracted and extended. This test should be repeated with the most forward c. g. position for landing regardless of weight. The same data specified in section 4b.141–1 (c) should be recorded.

(c) *Longitudinal trim during level flight, section 4b.142 (c).* The same configurations, test procedures and required data as are outlined in section 4b.141–1 should be followed in demonstrating longitudinal trim during level flight, section 4b.142 (c).

4b.143–1 *Procedure for demonstrating longitudinal, directional, and lateral trim (CAA policies which apply to sec. 4b.143).*

(a) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff.
C. G. position—most forward.
Wing flaps—retracted.
Landing gear—retracted.
Cowl flaps—appropriate for flight condition.
Operating engine(s)—maximum continuous power.
Critical inoperative engine—throttle closed on engine most critical for trim, propeller feathered.

(b) *Test procedure and required data.* It should be possible to maintain hands-off longitudinal, directional, and lateral trim during climb at a speed of 1.4 V_{s_1}. In addition to the data specified in section 4b.141–1 (b), the position of the critical inoperative engine and its corresponding propeller should be recorded.

4b.144–1 *Procedure for demonstrating trim for airplanes with four or more engines (CAA policies which apply to sec. 4b.144).*

(a) *Configuration.* This test should be conducted in the configuration that follows:

Weight—at which climb is equal to at least .01 $V_{s_0}^2$ at an altitude of 5,000 feet.
C. G. position—most forward.
Wing flaps—optional.
Landing gear—retracted.
Cowl flaps—appropriate for flight condition.
Operating engines—maximum continuous power.
Inoperative engines—throttles closed on outboard engine most critical for trim and on adjacent engine, propellers feathered.

(b) *Test procedure and required data.* It should be possible to maintain hands-off longitudinal, lateral, and directional trim at the same airspeed used in demonstrating the two-engine-inoperative climb (see sec. 4b.121). The following data should be recorded:

Weight.
C. G. position.
Wing flap position.
Landing gear position.
Operating engines, r. p. m., manifold pressure and cowl flap position.
Position of critical inoperative engines and their propellers.
Pressure altitude.
Ambient air temperature.
Climb speed.

Discussion of Policies Relating to the General Stability Qualities in Section 4b.150–1

Stability is closely related to trim in that if stability is absent, trimming is impossible. It should be noted that in sections 4b.151 through 4b.158 a great deal more attention is devoted to longitudinal stability than to the lateral stability because the longitudinal stability as affected by elevator control is intimately involved in the establishment of center of gravity limits, while the lateral characteristics ordinarily have negligible effect upon these limits. It should also be noted that, concerning longitudinal stability, the static stability is a function of positivity of return force as displayed at the pilot's controls, whereas the dynamic stability is specified in terms of the behavior which the airplane should exhibit when certain specific things are done with the elevator control. It has been attempted in this manual to cover those specific flight regimes in which stability is considered essential. It is believed that these are critical in the sense that if the required stability is obtained in these conditions it will probably also be obtained in any other flight condition likely to be encountered with the airplane.

4b.150–1 *General stability requirements (CAA policies which apply to sec. 4b.150).* If an airplane design is encountered in which critical stability conditions may exist other than those prescribed in sections 4b.151 through 4b.157 they should be investigated.

Discussion of Policies Relating to Procedure for Demonstrating Static Longitudinal Stability in Section 4b.151-1

Static stability is specified in terms of control forces because it is believed necessary and desirable to provide "feel" of the airplane for the pilot through this medium. Thus it may be seen that elimination of friction from the control system is an important factor which should be considered in connection with static stability. The elevator control force requirements prescribed in section 4b.151 will safeguard against inadvertent stalls or inadvertent elevator control operation at excessive speeds, providing easy handling qualities during instrument flight, and will generally hold to a minimum the amount of attention and skill required of a pilot during landings, takeoffs, and the other normal operating conditions.

4b.151-1 *Procedure for demonstrating static longitudinal stability (CAA policies which apply to sec. 4b.151).*

(a) Once the airplane has been trimmed, it should tend to maintain the trim speed so that a conscious effort is required by the pilot to depart from that speed. A forward pressure on the control column should be necessary to increase the airspeed and the reverse for a decrease in the airspeed. These forces should be such that departures in speed in either direction from the trim speed would require control column pressure that increases approximately proportionately as the speed departs from the trim speed.

(b) It should be possible to make such changes in speed as may be required to perform a maneuver without the necessity of readjusting the trim in order to relieve very high control forces which would otherwise be necessary. Figure 3 (p. 68) has been prepared to indicate what should be required in the way of static longitudinal stability qualities.

(c) When conducting the stability tests specified in sections 4b.152 through 4b.155, the elevator control force required to hold a given stabilized air speed should be measured at air speeds within the range specified by the requirements to define the curve of elevator control force versus air speed. The elevator control force should be measured at intervals of 20 m. p. h. in the region where the force indicates definite stability, and at 10 m. p. h. intervals when any change in stability becomes apparent. An elevator control force indicator should be installed in the airplane in order to obtain this data. During these tests the airplane should return to an airspeed within 10 percent of the original trim speed when the control is released slowly from speeds above and below the trim speed.

4b.152-1 *Procedure for demonstrating stability during landing (CAA policies which apply to sec. 4b.152).*

(a) *Configuration.* This test should be conducted in the configuration that follows:

- Weight—maximum landing.
- C. G. position—most forward and/or most forward at maximum landing weight and most aft.
- Wing flaps—maximum landing position.
- Landing gear—extended.
- Engines—power off, propellers windmilling.
- Cowl flaps—appropriate for flight condition.

(b) *Test procedure and required data.* The airplane should be trimmed at a speed of 1.4 V_{s_1} at any optional altitude (see sec. 4b.100-3 (c)). Static longitudinal stability should be demonstrated at speeds from just above the stall to 1.8 V_{s_1} (or placard speed). The elevator control force necessary to maintain each speed should be recorded at approximate even increments of velocity within the above speed range. The speed range representing the maximum friction band from which the airplane will not return to the trim speed should be recorded. For aircraft having an increase in stable elevator control force gradient with forward c. g. travel, only the maximum force need be checked at forward c. g. Lateral and directional trim should also be checked (see sec. 4b.141-1). The following data should be recorded:

- Weight.
- C. G. position.
- Wing flap position.
- Landing gear position.

Engines, r. p. m. and manifold pressure.
Pressure altitude.
Ambient air temperature.
Trim speed.
Elevator control force.

4b.153–1 *Procedure for demonstrating stability during approach (CAA policies which apply to sec. 4b.153).*

(a) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum landing.
C. G. position—most aft.
Wing flaps—approach position.
Landing gear—retracted.
Engines—power required for level flight at 1.4 V_{s_1}.
Cowl flaps—approach position.

(b) *Test procedure and required data.* The same procedures and data as outlined in section 4b.152–1 (b) should be followed in demonstrating stability for the approach configuration.

4b.154–1 *Procedure for demonstrating stability during climb (CAA policies which apply to sec. 4b.154).*

(a) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff.
C. G. position—most aft.
Wing flaps—retracted.
Landing gear—retracted.
Engines—75 percent maximum continuous power.
Cowl flaps—appropriate for flight condition.

(b) *Test procedure and required data.* The airplane should be trimmed at the best rate of climb speed except that this speed need not be less than 1.4 V_{s_1}. Static longitudinal stability should be demonstrated at speeds from just above the stall to the speed at which the control force becomes excessive but not to exceed V_{NE}. The curve of elevator control force vs. speed should have a stable slope between 85 percent and 115 percent of the trim speed and no reversal of elevator control force should occur throughout the speed range tested. Further test procedures and data to be recorded should be the same as are specified in section 4b.152–1 (b).

4b.155–1 *Procedure for demonstrating stability during cruising (CAA policies which apply to sec. 4b.155).*

(a) *Cruising, landing gear retracted, section 4b. 155 (a).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff.
C. G. position—most aft.
Wing flaps—retracted.
Landing gear—retracted.
Engines—75 percent maximum continuous power.
Cowl flaps—optional.

(2) *Test procedure and required data.* The airplane should be trimmed at the speed for level flight with 75 percent maximum continuous power. Static longitudinal stability should be demonstrated at speeds from just above the stall to the speed at which the control forces become excessive (50 lbs.), but not to exceed V_{NE}. Further test procedure and data to be recorded should be the same as are specified in section 4b.152–1 (b).

(b) *Cruising, landing gear extended, section 4b.155 (b).*

(1) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff.
C. G. position—most aft.
Wing flaps—retracted.
Landing gear—extended.
Engines—75 percent maximum continuous power or the power for level flight at the landing gear extended speed, V_{LE}, whichever is lesser.
Cowl flaps—appropriate for flight condition.

(2) *Test procedure and required data.* The airplane should be trimmed at the speed for level flight with 75 percent maximum continuous power or the power for level flight at the landing gear extended speed, V_{LE}, whichever is the lesser. Static longitudinal stability should be demonstrated at speeds from just above the stall to the speed at which the control forces become excessive (50 lbs.), but not to exceed V_{LE}. Further test procedures and data to be recorded should be the same as are specified in section 4b.152–1 (b).

4b.156–1 *Procedure for demonstrating dy-*

namic longitudinal stability (*CAA policies which apply to sec. 4b.156*). Damping of accelerations and movement of the control should be noted when:

(a) The control column is quickly offset and immediately released and

(b) The control column is quickly offset and immediately returned to the trim position and held in this position.

4b.157–1 *Procedure for demonstrating static directional and lateral stability* (*CAA policies which apply to sec. 4b.157*).

(a) No real motion of the airplane involving roll is possible without yaw also being involved, and vice versa. In showing compliance with section 4b.157 the rolling and yawing stability should be investigated separately.

(b) Directional stability may be investigated by starting from steady flight in the required configuration and deflecting the rudder at a fairly rapid rate by the amount required to maintain a steady skid with the airplane yawed approximately 20° (as read on the directional gyro) while the wings are maintained level by use of the ailerons, and the speed held constant by means of the elevator control. When the steady condition has been established, the rudder should be released and, if the airplane is directionally stable, it should cease to skid; i. e., the yaw should decrease to approximately zero and, if also laterally stable the aileron deflection and force required to hold the wings level should also approach zero. The test should be conducted by executing skids both to the right and left, recording in each case the time required from the release of the rudder controls and the number of oscillations, if any, involved to recover to steady level flight.

(c) Lateral stability should be investigated by starting from steady flight in the required configuration and banking the airplane approximately 20° (as read on the gyro horizon) by means of the ailerons, while maintaining the original heading by means of the rudder, and the original speed by means of the longitudinal trimming device. When the steady slipping condition has been established, the aileron control should be released. If the airplane is laterally stable, it should cease to slip; i. e., the wing should return to an approximately level attitude, and the rudder deflection and pedal force required to maintain the heading should approach zero. The test should be conducted by executing slips from both to right and left, and in each case the time required from the release of the aileron control and the number of oscillations, if any, involved to recover to steady level flight should be recorded.

(d) In addition to the directional and lateral stability tests, section 4b.157 (c) contains provisions which should be used to test the airplane for rudder overbalance.

(e) *Static directional stability test, section 4b.157 (a) and (c). CAUTION:* Prior to conducting this test and that in (f), complete agreement should be reached between the applicant and the CAA Flight Test Agent to insure that the severity of control application will not result in loads exceeding the design limitations.

(1) *Configuration.* This test should be conducted in the configurations that follow:

Maximum takeoff weight with wing flaps retracted.

Maximum landing weight with wing flaps extended.

C. G. position—most aft.

Wing flaps—retracted and maximum landing position.

Landing gear—retracted and extended.

(2) *Test procedure and required data.* The following tests should be conducted at the altitude deemed most critical for the combination of power and aerodynamic damping effect:

(i) The airplane should be yawed slowly to the left and right using ailerons to hold wings level, and, when controls are released slowly, the tendency of airplane to recover from the skid should be noted.

(ii) The qualitative proportionality of rudder and aileron deflection and force during steady straight sideslips should be noted.

(iii) Damping of yawing and movement of control should be noted when the rudder is quickly offset and immediately released and when the rudder is quickly offset and immediately returned and held in the trim position.

(3) The tests in (e) (2) of this section should be conducted in the following configurations:

(i) Flaps in landing position and gear extended, at 1.2 V_{s_1}, power off, and 75 percent maximum continuous power.

(ii) The flaps and gear retracted at 1.2 V_{s_1}, and V_c with 75 percent maximum continuous power.

(iii) Flaps and gear retracted at 1.2 V_{s_1}, with power off.

(4) The following data should be recorded for the tests specified in (e) (2) and (e) (3) of this section:

Weight.
C. G. position.
Wing flap position.
Landing gear position.
Engines, r. p. m. and manifold presure.
Pressure altitude.
Ambient air temperature.
Air speed at V_{FE}, 1.2 V_{s_1} and V_C.
Rudder force at maximum deflection.

(f) *Static lateral stability test, section 4b.157(b).*

(1) *Configuration.* This test should be conducted in the configurations that follow:

Maximum takeoff weight with flaps retracted.

Maximum landing weight with flaps extended.

C. G. position—most aft.

Wing flaps—retracted and maximum landing position.

Landing gear—retracted and extended.

(2) *Test procedure and required data.* The following tests should be conducted in the configurations specified in (e) (3) and at the altitude deemed most critical for the combination of power and aerodynamic damping effect.

(i) Starting from steady straight flight the airplane should be banked 20° while a constant heading is held; the aileron control should then be released. The stability as evidenced by the tendency to raise the low wing should be positive at high speed and should not be negative at 1.2 V_{s_1}.

(ii) Damping of rolling motion and movement of controls should be noted when the aileron is quickly offset and immediately released and also when the aileron is quickly offset and immediately returned and held in the trim position.

(iii) The same data as are specified in (e) (4) should be recorded at air speeds of 1.2 V_{s_1} and V_C.

4b.158–1 *Procedure for demonstrating dynamic directional and lateral stability (CAA policies which apply to sec. 4b.158).* Damping of yawing and movement of the control should be noted during the test procedure in section 4b.157–1 (e) (2) (iii).

Discussion of Policies Relating to Procedure for Demonstrating Stall Tests, Symmetrical Power in Section 4b.160–1

Flight tests have shown that the point of maximum lift in the time-history data may be obtained with sufficient accuracy from an accelerometer mounted perpendicular to the wing MAC axis if excessive angles-of-attack are not obtained. Mounting an accelerometer in this manner, however, gives acceleration along the normal force vector and not along the lift vector. This results in acceleration readings which are affected by longitudinal acceleration. Nevertheless, if a deceleration rate of not greater than 1 m. p. h./sec. $\left(\frac{1\times 1.467}{32.2}=.05g\right)$ is maintained in the stall maneuver, the effect of longitudinal acceleration will be negligible.

Indicated acceleration is affected by the angle which the vertical axis of the accelerometer makes with a perpendicular to the earth's surface. Thus, for very high stall angles an accelerometer mounted perpendicular to the MAC will indicate a decrease in load factor merely due to rotation of the instrument. Since it is theoretically desirable to obtain acceleration along the lift vector (perpendicular to the flight path), and since tests have shown that the flight path during the stall maneuver is approximately level regardless of configuration down to the stall, it seems obvious that mounting the accelerometer so that its vertical axis is offset from a line perpendicular to the wing MAC by an angle equal to the angle-of-attack for C_L max. will reduce error due to improper orientation of the accelerometer axis. At angle-of-attack for C_L max., $L=\eta W$ if angle-of-attack for C_L max. was properly chosen; the error in lift either side of L_{max}, will be off by the cosine of the angular difference between the actual angle-of-attack and the angle at which the accelerometer was set. Calculations show that any reasonable angular error in setting the accelerometer will not significantly affect the shape or location of the lift curve peak.

In regard to measurement of angle-of-attack, determination of true angle-of-attack would require calibration of the indicator for each of several configurations. However, compliance with the regulation does not require knowledge of true angle-of-attack but only assurance that true angle-of-attack is increasing steadily as the maximum lift is exceeded. Since calibration of known angle-of-attack devices shows that the difference between true angle and indicated angle is proportional to C_L, then knowledge of variation of indicated angle-of-attack during the stall maneuer will be sufficient.

4b.160–1 *Procedure for demonstrating stall tests, symmetrical power (CAA policies which apply to sec. 4b.160 (c) (2)).*

(a) The angle-of-attack during the stall maneuver should be increased at least to the point where the following two conditions are satisfied:

(1) Attainment of an angle-of-attack measurably greater than that for maximum lift.

(2) Clear indication to the pilot through the inherent flight characteristics that the airplane is stalled.

(b) The following procedure may be used to demonstrate that these two conditions are fulfilled:

(1) A photopanel or equivalent method of obtaining continuous records of the following variables at not greater than ¼ second intervals should be provided: indicated angle-of-attack, swivel static and shielded total pressure head or equivalent, pressure altitude, pitch and bank angle, normal acceleration, elevator position and force, aileron and rudder position.

(2) If it is evident that longitudinal stick force is always positive, that is, no reversal exists down to the stall, then time history of this item should not be required.

(3) In order to insure that an accurate recording of the indicated angle-of-attack is obtained, the sensing device should be located in a region where tuft surveys show that the streamlines undergo no radical change in direction up to the maximum angle contemplated. Regions well forward of the wing leading edge are desirable to keep the angular difference between true angle and indicated angle as small as possible.

(4) Means for indicating the stall-warning point and the point at which the pilot is informed by the inherent flight characteristics that the airplane is stalled should be provided. This may consist of a light on the photopanel operable by a switch mounted on the control wheel. In order to insure that the camera records the light image a time delay device may need to be incorporated in the light circuit in cases where camera speed is low.

(c) *Configuration.* Stalls should be conducted in the configurations noted in the following listings and with cowl flaps appropriate for the flight condition. Power-off stalls should be conducted with the engines idling and propellers in low pitch. For power-on conditions, stalls should be conducted with that power necessary to maintain level flight at a speed of 1.6 V_{s_1} with flaps in the approach position, landing gear retracted and maximum landing weight.

(1) Stalls—straight flight:

Gross weight	C. G.	Power	Flap	Gear
Max. Land	Most Fwd.	Off	Retr	Retr.[8]
Do	do	do	T. O.	Do.[8]
Do	do	do	Appr	Do.[8]
Do	do	do	Land	Ext.[8]
Do	do	On	Appr	Do.[9]
Do	do	do	Land	Do.[9]
Do	Most Aft	Off	Appr	Do.[9]
Do	do	do	Land	Do.[9]
Do	do	On	Appr	Retr.
Do	do	do	do	Ext.
Do	do	do	Land	Retr.
Do	do	do	do	Ext.
Max. T. O.	do	Off	Retr	Ext.[9]
Do	do	do	T. O.	Do.[9]
Do	do	On	Retr	Do.[9]
Do	do	do	T. O.	Do.[9]

[8] May be demonstrated during stalling speed tests. See section 4b.112.

[9] Use extended, unless, due to direction of C. G. shift with gear, retracted gear is more critical. If retracted is more critical use retracted position for these stalls.

(2) Stalls—30° banked turns:

Gross Weight	C. G.	Power	Flap	Gear	Direction
Max. T. O.	Most Aft	Off	Retr.	Retr.	To right
Do	do	do	do	do	To left
Do	do	On	do	do	To right
Do	do	do	do	do	To left
Max Land	do	Off	Land	Extend	To right
Do	do	do	do	do	To left
Do	do	On	do	do	Do.
Do	do	do	do	do	To right

(d) *Test procedure and required data.* The stall tests may be conducted at any optional altitude (see sec. 4b.100–3 (d)). The flight test procedure should be conducted in accordance with section 4b.160 (c) (1). The pilot should be provided with a yawmeter or equivalent means for maintaining the angle of yaw as near zero as possible. The operation of the photopanel recording system, previously described in (b) (1) of this section, should be started at least 20 m. p. h. above the stall speed and allowed to operate continuously until the stall recovery is completed. The pilot's indication of stall warning and the actual occurrence of the stall should be obtained. In addition to the data obtained on the photopanel shown in (b) (1) of this section, the following information should also be recorded:

Weight.
C. G. position.
Ambient air temperature.
Wing flap position.
Landing gear position.
Engines, r. p. m. and manifold pressure.

(e) *Data analysis.* Time histories should be plotted of the photopanel instruments. The stalling warning point (see sec. 4b.162–1) and the point at which "the inherent flight characteristics give a clear indication that the airplane is stalled" should be noted on the plots.

(1) Inspection of the plots will then show if the following two conditions are fulfilled:

(i) The indicated angle-of-attack increases steadily to a value measurably beyond that for maximum lift, and

(ii) The stall is evident to the pilot prior to initiation of recovery.

(2) Consideration should be given to the following points in the time-history analysis:

(i) The direction in which the elevator is moving, i. e., any nose down pitch or decrease in load factor not induced by inadvertent elevator motion,

(ii) Rudder and aileron movement with respect to uncontrollable roll,

(iii) The effect of lag in the airspeed system,

(iv) Rate of airspeed change,

(v) Effect of pitching velocity or rolling velocity on indicated angle-of-attack. If possible, angle-of-attack time history should be drawn through points where pitching or rolling velocity are small. If corrections are unavoidable, the angular correction is simply $\tan^{-1} pd/V$ where p is the rolling or pitching velocity, V is the true airspeed, and d is the distance from the pitch or rolling axis, as the case may be, to the sensing device. It should be noted that this correction is applicable to either true or indicated angle-of-attack.

(vi) The indicated acceleration is a function of the angle the vertical axis of the accelerometer makes with the perpendicular to the earth's surface. Therefore, bank angle will seriously affect the maximum lift point. For example, a bank of 45° without loss of lift will result in a drop in indicated acceleration from 1.00 to .707. As a result acceleration data obtained in the region of $C_{L\,max.}$ should be disregarded or corrected for bank angle when the bank angle exceeds nine or ten degrees.

4b.161–1 *Procedure for demonstrating stall tests, asymmetrical power (CAA policies which apply to sec. 4b.161).*

(a) During this test the airplane should not become uncontrollable or lose an excessive amount of altitude when so stalled.

(b) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff.
C. G. position—most aft.
Wing flaps—retracted.
Landing gear—retracted.
Operating engine(s)—power up to 75 percent maximum continuous power, cowl flaps optional.
Critical inoperative engine—propeller optional, feathered or windmilling, cowl

flaps appropriate for flight condition.

Trim speed—1.4 V_{s_1}.

(c) *Test procedure and required data.* This test may be conducted at any optional altitude (see sec. 4b.100–3 (c)). See section 4b.160 (c) regarding test procedure.

(1) The speed of the airplane should be reduced from the trim condition with the wings held level until the first of the following occurs:

(i) Full rudder or aileron deflection.

(ii) 180 lbs. rudder force.

(iii) Stall is reached.

(2) If full rudder or aileron deflection, or the 180 lbs. rudder force occurs first, the power should be reduced and the test repeated until sufficient control is available to complete the stall. The power may be reduced on the operating engine(s) before reapplying power on the operating engine or engines for the purpose of regaining level flight. The following data should be recorded at that point:

Pressure altitude.
Ambient air temperature.
Indicated air speed.
Engines, r. p. m. and manifold pressure.
Torque pressure.
Carburetor air temperature.
Rudder force (if desirable).

(3) If stall is reached first, the same data should be recorded.

Discussion of Policies Relating to Stall Warning in Section 4b.162–1

Occurrence of stall warning at some specific speed margin above the stalling speed is no longer required. It has been found that certain other characteristics may exist which make an airplane less susceptible to inadvertent stalling than one in which a specific speed margin has been provided between the occurrence of stall warning and the actual stall.

4b.162–1 *Stall warning (CAA policies which apply to sec. 4b.162).*

(a) The adequacy of stall warning should depend on the relative ease with which an airplane might be inadvertently stalled following the occurrence of stall warning. For example, if unmistakable warning occurs only 2 percent above the stall speed but undue pilot effort is required to reduce the airspeed to the stall, the speed margin of 2 percent may be adequate. On the other hand, if conscious effort is required to avoid stalling the airplane, a positive type of warning initiated at a relatively high speed above the stall may be required.

(b) Suggested suitable stall warnings are, buffeting which may be defined as general shaking or vibration of the airplane or elevator shake of sufficient magnitude to be unmistakable; or a stall warning instrument such as a stick shaker. A visual stall warning device which requires the attention of the crew within the cockpit is not considered acceptable by itself.

4b.170–1 *Procedure for demonstrating longitudinal stability and control on the ground (CAA policies which apply to sec. 4b.170).* Taxiing tests at velocities up to 70 percent of the stalling speed should be conducted on smooth and rough ground which may likely be encountered under normal operating conditions. Particular attention should be paid to the following:

(a) *Taxiing over rough ground.* There is some evidence to indicate that critical loads can be built up in taxiing over rough ground, even when the shock-absorbing system is entirely satisfactory with respect to capacity for landing purposes.

(b) *Brakes.* Their adequacy when maneuvering on the ground and their tendency to cause nosing-over should be investigated. Any bad tendency will normally be exaggerated when taxiing in a strong side or tail wind.

4b.171–1 *Procedure for demonstrating directional stability and control on the ground (CAA policies which apply to sec. 4b.171).*

(a) Compliance with the requirement of section 4b.171 (a) may be demonstrated during tests for the establishment of the cross wind component velocity in accordance with section 4b.173.

(b) Compliance with the requirement of section 4b.171 (b) may be demonstrated during power off landings in other tests.

(c) Compliance with the requirement of section 4b.171 (c) may be demonstrated during taxiing prior to takeoff or after landing from other flight tests.

4b.172–1 *Shock absorbing mechanism tests (CAA policies which apply to sec. 4b.172).* The shock absorbing mechanism should be checked for satisfactory operation while taxiing, taking off and landing during other tests in the type certification program.

4b.173–1 *Crosswind demonstration (CAA policies which apply to sec. 4b.173).*

(a) A crosswind component of not less than 0.2 V_{s_0} should be established during type tests. Consequently, two results are possible:

(1) A crosswind component may be established at a value which is not marginal with the airplane's handling characteristics. This value should be included in the Operating Procedures section of the Airplane Flight Manual. The operation of the aircraft in crosswinds greater than the value specified is not necessarily a hazard. Thus operation in crosswinds of a greater value is entirely within the discretion of the operator.

(2) A critical crosswind component may be established at a value which is considered the maximum up to which it is safe to operate the airplane on the ground, including takeoffs and landings. This value should be shown in the Operating Limitations section of the Airplane Flight Manual. Operation of the airplane in crosswinds above the maximum safe value is considered hazardous and the operator should do so only on the same emergency basis that a pilot would be justified in exceeding any of the operating limitations such as air speed, engine r. p. m., c. g. limitations, etc.

(3) An operator may of course restrict the operation of his airplane to crosswind components of any value equal to or less than that established during the type certification tests.

(b) *Configuration.* This test should be conducted in the configurations that follow:

Weight—maximum takeoff and landing.
C. G. position—most aft.
Flaps—takeoff and maximum landing positions.

(c) *Test procedure and required data.* At least three takeoffs and landings should be made in crosswind components of 0.2 V_{s_0} mph (or greater at applicant's option) to demonstrate satisfactory controllability and handling characteristics. The magnitude and direction of the crosswind should be established by the use of appropriate meteorological instruments.

4b.180–1 *Water handling qualities (CAA policies which apply to sec. 4b.180).* Policies outlined in section 4b.182–2 will apply.

4b.181–1 *Crosswind demonstration (CAA policies which apply to sec. 4b.181).* Policies outlined in section 4b.173–1 will apply.

4b.182–1 *Procedure for demonstrating control and stability on the water (CAA policies which apply to sec. 4b.182).*

(a) In order to check water stability, taxiing tests should be made in a crosswind determined in accordance with section 4b.181.

(b) Porpoising tendencies should be investigated and reported for extreme loading conditions.

(c) The ability to maneuver up to and while on the step should be investigated and the results reported.

(d) Compliance with the spray requirements may be substantiated while taxiing, taking off, and landing during other tests in the type certification program.

(e) If water rudders are provided, their effectiveness should be checked.

(f) Water taxiing ability should be investigated by actually taxiing the seaplane with appropriate use of power.

4b.190–1 *Determination of flutter and vibration qualities during dive (CAA policies which apply to sec. 4b.190).*

(a) The airplane should be observed for flutter and vibration tendencies during other tests in the type certification program. In case the design speed is limited at altitude by Mach number, the dive should be conducted at a combination of pressure altitudes and equivalent airspeed to permit attaining the desired maximum Mach number and dynamic pressure simultaneously. Stability and control qualities should be noted during the dive.

(b) *Configuration.* This test should be conducted in the configurations that follow:

(1) *Maximum takeoff weight.*
C. G. position—most aft.
Wing flaps—retracted and takeoff position.
Landing gear—retracted.
Engines—power as desired.
Cooling controls—optional.
Pneumatic boots—inoperative.

(2) *Maximum landing weight.*
C. G. position—most rearward
Wing flaps—approach and landing positions.
Landing gear—extended.
Engines—power as desired.
Cooling controls—optional.
Pneumatic boots—inoperative.

(c) *Test procedure and required data.* The speed of the airplane should be slowly increased, from a steady flight high speed condition, until the maximum calibrated design dive speed for maximum takeoff weight is attained. The power and trim may be adjusted during the dive. The dive should be entered at a sufficiently high altitude to insure safe recovery. In case the design speed is limited at altitude by Mach number, the airplane should be dived at constant Mach number (maximum design or highest desired by the applicant—but in no case less than that specified in section 4b.210 (b) (5)) until the maximum equivalent design dive speed is attained. The test should be repeated at maximum landing weight with flaps and gear extended diving to the maximum design flap speed or speeds. *CAUTION:* Throughout these tests any control displacements should be executed gently.

(1) The following data should be recorded for each test:
Pressure altitude.
Ambient air temperature.
Indicated air speed.
Machmeter reading (if applicable).
Engines, r. p. m. and manifold pressure.
Wing flap position.
Landing gear position.
Weight.
C. G. position.

4b.250–1 *Water loads—Alternate standards (CAA policies which apply to sec. 4b.250.)* ANC–3 provides a level of safety equivalent to, and may be applied in lieu of section 4b.250.

4b.324–1 *Procedure for demonstrating wing flaps that are not interconnected (CAA policies which apply to sec. 4b.324 (a)).* If the wing flaps are not mechanically interconnected, tests should be conducted to simulate flap malfunctioning (to the extent of the flaps being retracted on one side and extended on the other) during takeoffs, approaches, and landings to demonstrate that the airplane is safe under these conditions.

4b.334–1 *Procedure for testing landing gear retracting system (CAA policies which apply to sec. 4b.334).*

(a) *General, section 4b.334 (a).* The ability to extend and retract the landing gear at a speed of at least 1.6 V_{s_1} should be demonstrated. If no other satisfactory means of decelerating the airplane are provided (such as dive brakes or other high drag devices), the ability of the landing gear retracting mechanism and wheel well doors to withstand the flight loads should be demonstrated under the following conditions:
Power required for level flight.
Airspeed, at least 0.67 V_C.
Landing gear extended.

(b) *Emergency operation, section 4b.334 (c).* Extending the landing gear by use of the emergency system for demonstrating compliance with the requirement of this section may be accomplished during other tests in the flight program.

(c) *Operation test, section 4b.334 (d).* The time required to retract the landing gear at speed V_2 (see sec. 4b.116 (b)) should be demonstrated in flight under the following conditions:
Weight—optional.
C. G. position—optional.
Operating engine(s)—takeoff power.
Critical inoperative engine—propeller windmilling on engine most critical from the gear retraction standpoint.

It is also desirable to obtain the time required to extend the landing gear for purposes of information.

Discussion of Policies Relating to Brake Tests in Section 4b.337–1

The requirements of section 4b.337 are based upon the fact that compliance with the operating rules of section 40.70 of this subchapter will require great dependence upon the presence and proper functioning of brakes unless the runways involved are unusually long.

The nature and extent of the tests to show compliance with section 4b.337 (a) will necessarily depend upon a great many things such as the general arrangement of the landing gear, the design of the brake system, the extent to which the capacity of the brakes is used in establishing the landing distance required by section 4b.122, the amount of available performance data for the brakes, etc. The simplest possible procedure appears to be to determine the average deceleration during a landing ground roll without the use of brakes and then establish the landing distance required by section 4b.122 by using the brakes to the extent necessary to double the mean deceleration so established. It appears likely, however, that this procedure would result in excessive landing distance and might seriously limit the use of the airplane in operation.

4b.337–1 *Brake tests (CAA policies which apply to sec. 4b.337).* If it is desired by the applicant to make the maximum possible use of the brakes in establishing the landing distance, and if also the contribution of the brakes to the total deceleration is relatively large, the brake system should be designed to permit the application of slightly less than half the braking deceleration developed under the conditions specified in this section. The following dual system is recommended: Dual wheel elements (drums or disc units), transmitting elements, power sources, master cylinders, etc., connected to a single pedal on each rudder pedal, such that the failure of any single one of these would leave half the total braking capacity symmetrically disposed about the plane of symmetry of the airplane. With such a system it should be possible to show compliance with section 4b.337 (a) by means of calculation based upon the test data necessary to establish the landing distance plus the brake data calculated by the aircraft manufacturer.

If the system is designed so that under the conditions here specified appreciably less than half the total braking capacity remains or if the remaining capacity is asymmetrically disposed, tests should be conducted to determine that half the mean deceleration may in fact be developed and/or that the airplane may be safely controlled directionally while doing so.

(a) *General, section 4b.337 (a).* Such tests should be conducted as is deemed necessary to show compliance with the subject regulation. The deceleration rates should be determined as described in section 4b.123–2 (b) (3).

(b) *Brake controls, section 4b.337 (b).* General brake control force and operation should be noted throughout the flight test program to determine that they are satisfactory.

(c) *Parking brake controls, section 4b.337 (c).* During engine run-up prior to takeoff for other tests, the parking brake control should be set, and without further attention, a demonstration should be made to determine that sufficient braking is maintained to prevent the airplane from rolling on a paved runway while takeoff power is applied on the most critical engine.

4b.337–2 *Brake systems. (CAA policies which apply to sec. 4b.337.)* In order to obtain a minimum landing distance under section 4b.122 and at the same time meet the deceleration requirement of section 4b.337 (a) (2) in event of failure of the normal brake system, it is a common practice to provide an alternate brake system. When hydraulic (or pneumatic) brakes are used in the normal brake system, this alternate means usually consists of a duplicate hydraulic or pneumatic brake system and is commonly referred to as the "emergency brake system." The following items should be considered in the design of such systems:

(a) *Relationship between normal and emergency brake systems.* The systems for actuating the normal brake and the emergency brake should be so separated that a failure in, or the leakage of fluid from, one system will not render the other system inoperative. A hydraulic brake assembly may be common to both the normal and emergency brake systems if it is shown that the leakage of hydraulic fluid resulting from failure of the sealing elements in the brake assembly would not reduce the braking effectiveness below that specified in section 4b.337 (a) (2).

(b) *Brake control valves.* In the normal brake systems of all aircraft, the brake control valves should be of a type such that the pilots may exercise variable control of the pressure to the brakes. The foregoing provision need not necessarily apply to the emergency brake systems although obviously such a provision would be desirable. Flight tests should be conducted to determine that the normal and emergency brake systems fulfill the requirements of section 4b.170 (a) and (b).

In the normal brake systems of tail wheel type aircraft or of nose wheel type aircraft equipped with non-steerable nose wheels, provisions should be made for independently controlling the brakes on either side of the main landing gear in order that directional control of the aircraft can be maintained. (See sec. 4b.171 (c).) In the emergency brake systems of tail wheel type aircraft and in the normal and emergency brake systems of nose wheel type aircraft, it is desirable that independent control of the brakes on either side of the landing gear be provided although such control is optional.

4b.337–3 *Replacement or modified brakes* (*CAA policies which apply to sec. 4b.337*).

(a) *General.* Replacement or modified brake installations may be approved on the basis of dynamometer tests together with functional flight tests in lieu of measured accelerate-stop and landing distance flight tests if the decelerate performance based on dynamometer data is shown to be equal to or better than the original airplane flight test decelerate performance. Dynamometer tests which simulate actual airplane decelerate-distance tests may incorporate variable kinetic energy absorption rates simulating flight test deceleration conditions, and may include an energy allowance for the aerodynamic drag of the airplane which occurs during the deceleration portion of the accelerate-stop and landing runs. However, if any improvement in decelerate performance over that shown in the original Airplane Flight Manual is desired, then this policy is inapplicable and complete airplane flight tests will be required.

(1) The procedures of (c) through (g) may be used for substantiating replacement or modified brake installations and may be applied to approved brakes of any manufacturer. The replacement brake does not have to be manufactured by the maker of the original brake.

(2) Brakes which have been approved under TSO or preceding approval standards (whichever is pertinent) may be approved as a replacement brake on an existing airplane type upon the presentation of test reports and other pertinent computations showing:

(i) That, in sofar as deceleration performance is concerned, the replacement or modified brakes are equal to or better than the original brake installation on the basis of dynamometer tests contained in this section, and

(ii) That, the replacement or modified brakes when installed on the airplane, comply with the ground handling requirements of section 4b.170.

(b) *Brake modifications.* Modifications to a previously approved wheel-brake installation involving changes to component parts which will involve variations in kinetic energy absorption characteristics should be subjected to the dynamometer tests contained in (b) (1) in addition to the dynamometer tests specified in (e) and (f) for the accelerate–stop and landing conditions and should also include a check of operating and ground handling characteristics. Typical modifications which vary the kinetic energy absorption characteristics are as follows: changes of brake lining material, changes in brake discs or brake drum material, reductions in friction surface plan dimensions (area), etc.

(1) The minimum reliability standards for brakes referenced in TSO–C26 and contained in Specification AS227A should be used as a guide for modified brakes. However, section 5.4.3 of AS227A may be applied as follows for evaluating such modifications:

(i) Thirty tests simulating the stopping of an airplane at 100 percent kinetic energy.[10]

(ii) One test simulating the stopping of an airplane at 125 percent kinetic energy.[10]

(c) *Determination of kinetic energy requirements.*

(1) In the case of replacement brakes (that is, those brakes incorporating major design differences from those originally tested on the airplane) the kinetic energy (K.E.) to be absorbed on the dynamometer in compliance with provision (a) (2) of this section should be deter-

[10] The modifier of the brake should substantiate the fact that the original brake approval tests and the tests specified in (i) and (ii) were conducted under similar conditions and that the modified brake assembly is at least the equal to that previously approved as an equipment item insofar as energy absorption and stopping time are concerned.

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mined in accordance with the following formula:

$$K.E._{DYN} = K.E._{WV} - \tfrac{1}{2}\, K.E._{AD}$$

where:

$K.E._{WV}$ = the maximum kinetic energy as determined from the most critical combination of weight and speed (in terms of ground speed). In determining the maximum speed, the effects of tailwind, altitude and flap setting should be taken into account.

$K.E._{AD}$ = the kinetic energy absorbed by aerodynamic drag of the airplane during the deceleration portion of the accelerate–stop and landing runs. This kinetic energy should be determined from available test data of the airplane or by other reliable calculations based on the basic parameters for the type of airplane involved.

(2) In the case of brakes modified as described in paragraph (b) the kinetic energy to be absorbed on the dynamometer should be determined in accordance with the following formula:

$$K.E._{DYN} = K.E._{WV} - K.E._{AD}$$

(i) This formula should not apply to modifications of a replacement brake which has been approved in accordance with (1) of this paragraph. Such modifications of a replacement brake should meet the same dynamometer requirements as the replacement brake did when originally installed.

(d) *Dynamometer test method.*

(1) There should be no artificial cooling of the brakes during dynamometer tests. Ventilating air flowing normal to the tire tread is permissible.

(2) For wheel-brake installations where dual or duplex brakes are used, the dynamometer test should be conducted on an entire wheel-brake unit.

(3) Brake lining should not be run-in to a degree which would be greater than the run-in for new lining when installed on an airplane prior to being put in regular airline service.

(4) Due to wing-lift acting on the airplane, the dynamometer tests should account for tire rolling friction due to the differential in braking effect resulting from the varying rolling radius of the tire on the runway as compared to the constant tire radius at constant tire deflection which occurs throughout the entire dynamometer run.

(5) The dynamometer mass should be corrected so that the selected inertia equivalent (I.E.) will result in a correct or conservative kinetic energy test value.

(6) During dynamometer testing a variable brake pressure, which does not exceed that pressure which is available from the airplane brake system intended for use with the replacement brake, should be used in duplicating as nearly as practicable the original airplane torque-speed and velocity-time flight test data corrected for aerodynamic drag and tire rolling friction.

(e) *Accelerate-stop distance test.* This condition is normally the most critical from a kinetic energy standpoint. The original flight test accelerate-stop deceleration camera data obtained during the type certification tests of the airplane should be obtained and corrected for aerodynamic drag and tire rolling friction.

(1) Continuous records of dynamometer torque-speed or velocity-time data for at least three of the runs, when absorbing the required kinetic energy for the critical combination of take-off weight and V_1 speed, should duplicate, as nearly as practical, the original airplane brake deceleration data. These dynamometer records should be converted to corrected and faired velocity versus distance values and be plotted and superimposed on the curve for the original airplane velocity-distance data, and

(2) The average of the above three corrected dynamometer velocity-distance curves should be superimposed on the curve for the original airplane velocity-distance data.

(3) The curves plotted in (1) and (2) of this paragraph should compare favorably with the original corrected flight data over the entire speed range and should indicate that, from any given speed, the airplane stopping distance would be equal to or less than the distance resulting from the original brake installation at the required kinetic energy level

corresponding to the actual accelerate-stop conditions which prevailed during the airplane type certification tests.

(4) If, in compliance with (1) of this paragraph, velocity-time data are submitted in lieu of torque-speed data, then sufficient spot-check calculations of the velocity-time data should be made to insure an accuracy comparable to the accuracy of torque-speed data. Inasmuch as torque-speed data are useful for airplane modification and design purposes, it is desirable that comparable and complete torque-speed data be included in the data submitted.

(5) Dynamometer time history recordings of brake pressure, torque, speed, and calculations for aerodynamic drag, tire rolling friction, and dynamometer mass correction, and all pertinent airplane data, should be submitted, together with an analysis showing the detailed calculations and charts necessary to establish the speed-distance relationship and comparison with the original airplane deceleration test data.

(f) *Landing distance test.* In order to substantiate landing distances, at least three dynamometer runs, using the critical combinations of landing weight and contact speed, should be conducted on the same brake unit. Landing distance data, compiled in accordance with the method described in (e) for accelerate-stop evaluation, should be submitted. The landing distance data, which are comparable to those of (e) for the accelerate-stop data, should compare favorably with the corrected airplane flight test results obtained with the original brakes in order to substantiate the adequacy of the replacement brakes, insofar as landing distances are concerned.

(g) *Aircraft functional tests.* The brakes should be tested on the airplane to determine their functional characteristics as indicated in (a) (2). Functioning characteristics should be observed during taxi and engine run-up conditions and at least three normal takeoffs and landings, at the maximum landing weight, should be conducted. During these tests, the brakes should be checked for any undesirable characteristics such as "grabbing," "fading," etc., and should at least be visually inspected, without dismantling, at the completion of the test in order to determine any evidence of malfunction or failure. If no malfunctioning has occurred, this visual inspection is adequate, but if malfunctioning does occur, a thorough inspection should be conducted. If any characteristics arise which indicate that stopping distances would exceed the original values in the CAA Approved Airplane Flight Manual, then the Administrator may require actual camera recorded airplane deceleration tests or any other tests deemed necessary to establish the adequacy of the brakes.

4b.350–1 *Noise and vibration characteristics (CAA policies which apply to sec. 4b.350 (g)).* Noise and vibration characteristics should be observed throughout the flight test program. If possible, noise levels should be measured and recorded in decibels.

4b.351–1 *Procedure for demonstrating pilot compartment visibility (CAA policies which apply to sec. 4b.351).*

(a) *Nonprecipitation conditions.* Such tests as are deemed necessary to show compliance with section 4b.351 (a) should be conducted.

(b) *Precipitation conditions, section 4b.351 (b).*

(1) The operation of the windshield wiper should be checked in actual or simulated precipitation conditions in order to demonstrate that adequate vision is provided for takeoff and landing at speeds up to 1.6 V_{s_1}.

(2) The windshield de-icing system should be checked for distribution and operation.

4b.353–1 *Control tests (CAA policies which apply to sec. 4b.353).* Such tests as are deemed necessary to show compliance with the control movements and locations specified in section 4b.353 should be conducted.

4b.358–1 *Application of loads (CAA policies which apply to sec. 4b.358).* The actual forces acting on seats, berths, and supporting structure in the various flight, ground and emergency landing conditions will consist of many possible combinations of forward, sideward, downward, upward, and aft loads. However, in order to simplify the structural analysis and testing of these structures, it will be permissible to assume that the critical load in each of these directions, as determined from the prescribed flight, ground, and emergency landing conditions, acts separately. If the applicant desires, selected combinations of loads may be used, provided the required strength in all specified directions is substantiated. (TSO C–25, Aircraft Seats and Berths, outlines acceptable methods for testing seats and berths).

4b.371–1 *Carbon monoxide detection* (*CAA policies which apply to sec. 4b.371*). Policies outlined in section 4b.467–1 will apply.

4b.372–1 *Combustion heaters equipped with carbon dioxide fire extinguishers* (*CAA policies which apply to sec. 4b.372*). The policies as outlined in section 4b.484–1 apply.

4b.380–1 *Protective breathing equipment* (*CAA policies which apply to sec. 4b.380* (*c*)). The policies outlined in section 4b.651–2 apply.

4b.384–1 *Cargo and baggage compartments equipped with carbon dioxide fire extinguishers* (*CAA policies which apply to sec. 4b.384*). The policies outlined in section 4b.484–1 apply.

4b.400–1 *Engine and propeller operation* (*CAA policies which apply to sec. 4b.400*). The engines and propellers should be observed during the flight test program to determine satisfactory operation of these systems and their associated components.

4b.401–1 *Approval of automatic propeller feathering system* (*CAA policies which apply to sec. 4b.401* (*c*)). All parts of the feathering device which are integral with the propeller or attached to it in a manner that may affect propeller airworthiness should be considered from the standpoint of the applicable provisions of Part 14. The determination of the continuing eligibility of the propeller under the existing type certificate, when the device is installed or attached, will be made on the following basis:

(a) The automatic propeller feathering system should not adversely affect normal propeller operation and should function properly under all temperature, altitude, airspeed, vibration, acceleration, and other conditions to be expected in normal ground and flight operation.

(b) The automatic device should be demonstrated to be free from malfunctioning which may cause feathering under any conditions other than those under which it is intended to operate. For example, it should not cause feathering during:

(1) Momentary loss of power.

(2) Approaches with reduced throttle settings.

(c) The automatic propeller feathering system should be capable of operating in its intended manner whenever the throttle control is in the normal position to provide takeoff power. No special operations at the time of engine failure should be necessary on the part of the crew in order to make the automatic feathering system operative.

(d) The automatic propeller feathering installation should be such that not more than one engine will be feathered automatically even if more than one engine fails simultaneously.

(e) The automatic propeller feathering installation should be such that normal operation may be regained after the propeller has begun to feather automatically

(f) The automatic propeller feathering installation should incorporate a switch or equivalent means by which to make the system inoperative (See also sec. 4b.10–2.)

4b.401–2 *Propeller feathering system operational tests* (*CAA policies which apply to sec. 4b.401* (*c*)).

(a) Tests should be conducted to determine the time required for the propeller to change from windmilling (with the propeller controls set for takeoff) to the feathered position at the takeoff safety speed, V_2.

(b) The propeller feathering system should be tested to demonstrate nonrotation up to 1.2 times the maximum level flight speed with one engine inoperative or the speed employed in emergency descents whichever is higher with:

Critical engine—inoperative.
Wing flaps—retracted.
Landing gear—retracted.
Cowl flaps—closed.

A sufficient speed range should be covered to assure that the propeller feathering angle established on the basis of the high speed requirement should not permit rotation in reverse at the lower speeds. In addition, the propeller should not inadvertently unfeather during these tests.

(c) In order to demonstrate that the feathering system operates satisfactorily, the propeller should be feathered and unfeathered at the maximum operating altitude established in accordance with section 4b.722. The following data should be recorded:

Time to feather propeller at the one-engine-inoperative cruising speed.

Time to unfeather propeller to 1000 r. p. m. at maximum operating altitude and one-engine-inoperative cruising speed.
Altitude of propeller feathering tests.
Ambient air temperature of propeller feathering tests.

4b.406–1 *Fluid type propeller de-icing test (CAA policies which apply to sec. 4b.406).* If the propellers are equipped with fluid type de-icers, the flow test should be conducted starting with a full tank of fluid and operated at maximum flow for a 15 minute timed period. The operation should be checked at all engine speeds and powers. The tank should be refilled to determine the amount of fluid used after the airplane is landed.

4b.416–1 *Unusable fuel (CAA interpretation which applies to sec. 4b.416).* The unusable fuel shoud be considered that fuel drainable from the tank sump with the airplane on the ground in a normal attitude with the wings leveled laterally after a fuel tank runout [11] test has been made.

4b.416–2 *Determination of unusable fuel supply and fuel system operation (CAA policies which apply to sec. 4b.416).*

(a) *General test program.* Tests for unusable fuel may be conducted at optional altitudes with all engines operating. The auxiliary fuel pumps should be turned "off" or "on" during the tests depending upon the normal operating procedure established for the airplane, or if the auxiliary pumps are being considered for use as emergency pumps they should be inoperative to at least 6,000 feet. The unusable fuel should be determined in each unique tank selection arrangement used for takeoff and landing by making runouts during the most critical of the three conditions specified in (b), (c), and (d). When a runout occurs, the fuel selector switch should be turned to a full tank. It should be possible to regain engine fuel pressure in not more than 20 seconds after switching to any full tank when engine malfunctioning has become apparent due to depletion of the fuel supply in any tank from which the engine can be fed after the airplane has been restored to a level flight condition. The tanks should be drained after landing to determine the unusable fuel quantity. In the case of fuel in tanks other than those used for takeoff and landing, the unusable fuel should be determined in the manner prescribed in (b) or during ground tests.

(b) *Level flight at maximum continuous power or at the power required for level flight at V_C whichever is the lesser, section 4b.416 (b) (1).*

(1) *Configuration.* This test should be conducted in the configuration that follows:
Weight—optional.
C. G. position—optional.
Wing flaps—retracted.
Landing gear—retracted.
Cowl flaps—optional.

(2) *Test procedure.* See (a).

(c) *Climb with takeoff power at speed V_2, section 4b.416 (b) (2).*

(1) *Configuration.* This test should be conducted in the configuration that follows:
Weight—nor more than maximum landing weight.
C. G. position—optional.
Wing flaps—takeoff position.
Landing gear—retracted.
Cowl flaps—optional.

(2) *Test procedure.* See (a).

(d) *Rapid application of maximum continuous power and subsequent transition to a climb at a speed V_2 determined in accordance with section 4b.114 (b), with retraction of flaps and landing gear, from a power-off glide at 1.3 V_{s_0}, with flaps and landing gear down at landing weight, section 4b.416 (b) (3).*

(1) *Configuration.* This test should be conducted in the configuration that follows:
C. G. position—optional.
Cowl flaps—optional.

(2) *Test procedure.* See (a).

4b.417–1 *Hot weather fuel system tests (CAA policies which apply to sec. 4b.417).*

(a) Hot weather fuel system tests should be conducted with fuel in the tanks normally used for takeoff and landing and with the maximum number of engines drawing fuel from the tank as would normally occur in flight. In the case of symmetrical fuel tank systems, the tests may be confined to one of each such system. Unweathered fuel should be used during these demonstrations. The fuel temperature should be 110° F. just prior to takeoff. If the fuel

[11] A fuel tank runout is considered to have occurred when the engine fuel pressure shows a marked decrease and/or the first evidence of engine malfunctioning occurs.

must be heated to this temperature, caution should be taken to prevent overheating during the process. The auxiliary fuel pumps should be turned "off" or "on" during the tests depending upon the normal operating procedure established for the airplane. If the auxiliary pumps are being considered for use as emergency pumps they should be inoperative to at least 6,000 feet. A fuel pressure failure is considered to occur when the fuel pressure decreases below the minimum prescribed by the engine manufacturer.

(b) *Configuration.* This test should be conducted in the configuration that follows:

Weight—corresponding to operation with full fuel tanks, minimum crew and ballast required to maintain airplane within center of gravity limits.

C. G. position—optional, within allowable limits.

Wing flaps—most favorable position.

Landing gear—retracted.

Cowl flaps—in a position that provides adequate cooling in the hot day condition.

Engines—See (c).

(c) *Test procedure and required data.* The takeoff and climb should be made as soon as possible after the fuel in the tank has been heated to 110° F. All engines should be operating at the takeoff power from 1,000 feet below through the takeoff critical altitude for a time not exceeding the takeoff time limitation. The power should be reduced to maximum continuous power for the remainder of the climb. The airspeed during the climb should not exceed that speed used in demonstrating the requirements specified in section 4b.119(a). If the engines are normally operated with the auxiliary pumps "off," they should be turned "on" when a fuel pressure failure occurs. Restoration of fuel pressure should be noted and the climb continued to the maximum operating altitude selected by the applicant for certification. The following data should be recorded at reasonable time intervals:

Fuel temperature at start of test.

Fuel pressure at start of test and continuously during climb noting any pressure failures.

Auxiliary fuel pump operation.

Pressure altitude.

Ambient air temperature.

Airspeed.

Engines, r. p. m. and manifold pressure.

Comments on engine operation.

4b.418–1 *Determination of fuel flow between interconnected tanks (CAA policies which apply to sec. 4b.418).* If there is a possibility of flow between interconnected tanks, it should be demonstrated that this flow is not sufficient to cause fuel to overflow from the tank vents during the conditions specified in section 4b.416(b) for the determination of unusable fuel. These maneuvers should be accompanied by side slips, skids and other uncoordinated maneuvers that might occur in normal service. The tests should be conducted with full tanks.

4b.426–1 *Determination of syphoning of fuel system vents (CAA policies which apply to sec. 4b.426).* Taxiing tests should be conducted which involve sharp turns followed by rapid acceleration into the takeoff run and other ground maneuvers to assure that fuel will not escape from, or syphon from, the tank vents; nor should syphoning occur under the flight conditions specified in the test program for section 4b.418–1. All tests should be conducted with full tanks.

4b.430–1 *Main fuel pump operational tests (CAA policies which apply to sec. 4b.430 (a)).* The ability to operate engines at an altitude of 6,000 feet using engine-driven fuel pumps alone should be demonstrated. The same procedure as outlined in section 4b.417–1 (c) for hot fuel tests should be followed. (This may be a ground test.)

4b.437–1 *Test procedure for fuel jettisoning (CAA policies which apply to sec. 4b.437).*

(a) In the case where the maximum takeoff weight exceeds 105 percent of the maximum landing weight, provisions should be available for jettisoning fuel from the maximum takeoff weight to the maximum landing weight at the corresponding altitude range of airports for which certification is sought. If the applicant has made sufficient jettisoning tests [12] to prove the safety of the jettisoning system, the tests

[12] The basic purpose of these tests is to determine that the required amount of fuel may be safely jettisoned under reasonably anticipated operating conditions within the prescribed time limit without danger from fire, explosion, or adverse effects on the flying qualities.

may be made with fuel only. Otherwise, preliminary tests should be made with noninflammable fluid first and the results then checked using fuel. The following procedures and methods should be observed for demonstrating the operation of the fuel jettisoning system:

(1) *Fire hazard.*

(i) Fuel in liquid or vapor form should not impinge upon any external surface of the airplane during or after jettisoning. Colored fuel, or surfaces so treated that liquid or vaporous fuel changes the appearance of the airplane surface may be used for detection purposes. Other equivalent methods for detection may be acceptable.

(ii) Fuel in liquid or vapor form should not enter any portion of the airplane during or after jettisoning. The fuel may be detected by its scent, combustible mixture detector or by visual inspection. In supercharged aircraft the presence of liquid or vaporous fuel should be checked with the airplane unpressurized.

(iii) There should be no evidence of fuel valve leakage after it is closed.

(iv) If there is any evidence that wing flap positions, other than that used for the test may adversely affect the flow pattern, the airplane should be placarded "Fuel should not be jettisoned except when flaps are set at —°."

(v) The applicant should select for demonstration the tanks or tank combinations which are critical for demonstrating the flow rate during jettisoning.

(vi) Fuel jettisoning flow pattern should be demonstrated from all normally used tank or tank combinations on both sides of airplane whether or not both sides are symmetrical.

(vii) Fuel jettisoning rate may be demonstrated from only one side of symmetrical tank or tank combinations which are critical for flow rate.

(viii) Fuel jettisoning rate and flow pattern should be demonstrated when jettisoning from full tanks using fuel.

(2) *Control.*

(i) Changes in the airplane control qualities during the fuel jettisoning tests should be noted.

(ii) Discontinuance of fuel jettisoning should be demonstrated in flight.

(3) *Residual fuel.* The residual fuel should be measured by draining the tanks from which fuel has been jettisoned in flight, measuring the total drained fuel and subtracting from the total the unusable fuel quantity for each tank to determine if there is sufficient reserve fuel after jettisoning to meet section 4b.437. This may be a ground test.

(b) *Configuration.* Fuel jettisoning tests should be conducted in the configurations that follow:

(1) *Glide.*

Weight—maximum takeoff.

C. G. position—optional.

Wing flaps—retracted or in a position desired for approval.

Landing gear—retracted or extended as desired by applicant.

Engines—power off, propellers windmilling.

Cowl flaps—optional.

Airspeed—1.4 V_{s_1}.

(2) *Climb.*

Weight—maximum takeoff.

C. G. position—optional.

Wing flaps—retracted or in a position desired for approval.

Landing gear—retracted or extended.

Operating engine(s)—maximum continuous power, cowl flaps optional.

Critical inoperative engine—throttle closed on engine most critical for fuel flow pattern, propeller feathered, cowl flaps closed.

Airspeed—one engine inoperative best rate of climb speed.

(3) *Level flight.*

Weight—maximum takeoff.

C. G. position—optional.

Wing flaps—retracted or in a position desired for approval.

Landing gear—retracted or extended.

Engines—power required for airspeed of 1.4 V_{s_1}.

Cowl flaps—optional.

(c) *Test procedure and required data.* When the airplane is trimmed in the configuration specified in items (b) (1) and (b) (2), the jettisoning valves should be opened and allowed to remain open until all jettisoning liquid has been disposed. If the configuration of (b) (3) is critical, tests should also be conducted for this condition. This procedure may be carried out in segments if desired. The following data should be recorded:

Time to jettison fuel.
Fuel gauge quantity at reasonable time intervals.
Pressure altitude.
Indicated airspeed.
Engines, r. p. m. and manifold pressure.
Carburetor air temperature.

4b.440–1 *Procedure for demonstrating oil cooling (CAA policies which apply to sec. 4b.440 (e)).* Procedures for conducting cooling tests are those outlined in sections 4b.452–1 and 4b.453–1.

4b.449–1 *Procedure for demonstrating propeller feathering (CAA policies which apply to sec. 4b.449).* Tests should be conducted to demonstrate that the oil reserve for propeller feathering is adequate to accomplish the feathering procedure. This may be done on the ground by using an auxiliary source of oil for lubricating the engine during its operation.

4b.452–1 *Procedure for demonstrating cooling climb (CAA policies which apply to sec. 4b.452).*

(a) If the applicant is not able to provide data for the location of the engine having the hottest cylinder heads and bases, the following procedure should be accomplished. The cylinder heads and bases on one engine should be fully instrumented for the purpose of determining the location of the hottest cylinder head and base to be checked during the climb cooling. Thermocouples should be installed on one head of each of the remaining engines at the location shown to be critical on the fully instrumented engine. The hottest of the critical cylinder heads may be determined by measuring the temperatures of each of the engines under simulated climb conditions. The engine having the hottest cylinder head should be chosen as the engine to be tested for the cooling demonstration. Instruments for determining the oil inlet and cylinder base temperatures should be installed on this engine. The cooler operating outboard engine should be considered to be the critical inoperative engine unless there is reason to believe that another engine is more critical. The cooling tests should be conducted in an atmosphere which is free of any visible moisture.

(b) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff.
C. G. position—optional.
Wing flaps—optional.
Landing gear—optional.
Operating engine(s)—maximum continuous power, mixture setting the same as used in normal operation and cooling controls in CAA hot day cooling position.
Critical inoperative engine—throttle closed on cooler operating outboard engine, propeller feathered and cowl flaps closed.

(c) *Test procedure and required data.*

(1) Prior to commencing the cooling climb, the engine temperatures should be stabilized in level flight at the lower of the two altitudes specified in section 4b.452 (c). During level flight the cooling climb conditions should be simulated by adjusting the airplane configuration to that shown in (b) and maintaining the necessary power on the operating engine(s) to obtain the speed specified in section 4b.452 (d).

(2) When the temperatures have stabilized, i. e., the rate of temperature change is less than 2° F. per minute, the propeller on the inoperative engine should be feathered and the cooling climb commenced at maximum continuous power and at the specified configuration and speed. The climb should be continued for five minutes after occurrence of the highest temperature or until the maximum altitude desired for certification is reached.

(3) The above procedure should be repeated when demonstrating engine cooling for high blower except that temperatures should be stabilized in level flight with simulated climb conditions at an altitude of 1,000 feet below the critical altitude established for the high blower. The weight of the airplane should be such that it will permit a rate of climb equal to that specified in section 4b.120 (c).

(4) The following data should be recorded at no greater than one minute intervals:

Pressure altitude.
Ambient air temperature.
Engines, r. p. m. and manifold pressure.
Carburetor air temperature.
Indicated airspeed.
Hottest cylinder head temperature.
Hottest cylinder base temperature.
Oil inlet temperature.

Coolant temperature.
Fuel flow.

(5) In addition a record should be made of the mixture setting, blower setting, cooling control settings, and fuel grade.

4b.453–1 *Procedure for demonstrating takeoff cooling (CAA policies which apply to sec. 4b.453).*

(a) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff.
C. G. position—optional.
Wing flaps—takeoff position.
Landing gear—optional.
Operating engine(s)—takeoff r. p. m. or full throttle, mixture setting at takeoff and cooling controls in takeoff position.
Critical inoperative engine—throttle closed on cooler operating outboard engine (see sec. 4b.452–1 (a)), propeller feathered and cowl flaps in optional position.

(b) *Test procedure and required data.* The temperature should be permitted to stabilize during level flight at the lowest practical altitude using 75 percent maximum continuous power on all engines and normal takeoff cowl flap or coolant door setting. After the temperatures have stabilized, the configuration of the airplane should be adjusted as specified in (a) of this section and the climb commenced at the speed and continued for the same time interval as takeoff power is used during determination of the takeoff flight path (sec. 4b.116). At the end of the takeoff power time limit, the power should be reduced to maximum continuous. After power has been reduced, the configuration may be adjusted to the en route condition specified in section 4b.452–1 (b) and the airplane accelerated to the en route climb speed specified in section 4b.452 (d). The cooling climb should be continued for five minutes after the occurrence of the highest temperature. The same data as outlined in section 4b.452–1 (c) (4) and (5) should be recorded.

4b.454–1 *Procedure for demonstrating cooling for seaplanes during water taxiing operations (CAA policies which apply to sec. 4b.454).*

(a) The cooling test for seaplanes should be conducted while taxiing on water. The tank system should contain fuel of the minimum grade approved for the engine installed. Cylinder and oil inlet temperatures should be permitted to stabilize in flight or by taxiing at reduced speed. The test should be conducted in an atmosphere which is free of visible moisture.

(b) *Configuration.* This test should be conducted in the configuration that follows:

Weight—maximum takeoff.
C. G. position—optional.
Wing flaps—optional.
Engines—sufficient power for airspeed required in (c).
Cooling controls—takeoff position.
Mixture setting—normal position for taxiing.

(c) *Test procedure and required data.* After temperatures have stabilized, the seaplane should be taxied down wind for at least 10 minutes at a speed which is not more than 5 m. p. h. above the step speed. The same data as outlined in section 4b.452–1 (c) (4) and (5) should be recorded.

4b.461–1 *Procedure for demonstrating carburetor air heat rise (CAA policies which apply to sec. 4b.461 (b)).*

(a) The carburetor air temperature should be measured by a minimum of three thermocouples so arranged as to give an average air mixture temperature. This indicator should be calibrated prior to the test. The tests should be conducted at an altitude where the free air temperature is 30° F. or at two altitudes of different temperatures, one of which is near 30° F.

(b) *Configuration.* This test should be conducted in the configuration that follows:

Weight—optional.
C. G. position—optional.
Wing flaps—optional.
Landing gear—optional.
Engines—60 percent maximum continuous power.
Cowl flaps—appropriate for flight condition.
Mixture setting—normal cruising position.

(c) *Test procedure and required data.*

(1) After all temperatures have stabilized (i. e., when the rate of temperature change is less than 2° F. per minute) and with the airplane in level flight and full cold carburetor at

60 percent maximum continuous power, the following data should be recorded:

Pressure altitude.
Ambient air temperature.
Indicated airspeed.
Carburetor air temperature.
Engines, r. p. m. and manifold pressure.
Torque pressure.
Mixture setting.
Cowl flap setting.

(2) Preheat should then be applied slowly (power may be restored to 60 percent maximum continuous at the applicant's option) and the above data recorded again after the carburetor air temperature has stabilized. The carburetor heat rise should be determined from the results of the data.

4b.465–1 *Procedure for demonstrating carburetor air cooling (CAA policies which apply to sec. 4b.465).* Carburetor air cooling should be demonstrated in conjunction with the tests required by sections 4b.452 and 4b.453.

4b.467–1 *Carbon monoxide detection (CAA policies which apply to sec. 4b.467 (a) (1) and (d)).*

(a) Any acceptable carbon monoxide detection method may be used in demonstrating compliance with section 4b.467 (a) (1) and (d), and with the ventilating requirements of section 4b.371. The tests should be conducted with the airplane's heater system in operation if there is any possibility of a system containing carbon monoxide. In aircraft employing thermal de-icing, tests should be conducted with the system operating at full capacity.

(b) *Configuration.* Carbon monoxide tests should be conducted in the configurations that follow:

(1) *Power-on level flight.*
Weight—optional.
C. G. position—optional.
Wing flaps—retracted.
Landing gear—retracted.
Engines—maximum continuous power.
Cowl flaps—appropriate for flight condition.

(2) *Power-off glide.*
Wing flaps—retracted.
Landing gear—retracted.
Engines—idling.
Cowl flaps—appropriate for flight condition.

(3) *Power approach.*
Wing flaps—approach position.
Landing gear—extended.
Engines—power for level flight.
Cowl flaps—appropriate for flight condition.
Airspeed—any speed from 1.4 V_{s_1} to 1.6 V_{s_1}.

(c) *Test procedure and required data.* The air should be sampled with a carbon monoxide indicator in front of cabin heater opening(s) with heat on and at representative passenger and crew locations. If the airplane does not have pressurization equipment installed, the air should be sampled at the above locations with the windows closed and also partially opened. If the airplane is equipped for pressurization, carbon monoxide indications should be taken when the cabin is pressurized and also unpressurized.

4b.467–2 *Determination of exhaust gas interference with visibility (CAA policies which apply to sec. 4b.467 (a) (5)).* The effects of exhaust gas interference with visibility should be observed during tests to demonstrate other night flying requirements.

4b.484–1 *Determination of carbon dioxide concentration in flight crew compartments. (CAA policies which apply to sec. 4b.484 (b)).*

(a) Carbon dioxide has been found to adversely affect flight crew personnel in the performance of their duties. Therefore, in aircraft equipped with built-in carbon dioxide fuselage compartment fire extinguishing systems, the carbon dioxide concentration occurring at the flight crew stations as a result of discharging the fire extinguishers should be determined in accordance with paragraphs (b) and (c), except that such determination is not considered necessary if:

(1) Five pounds or less of carbon dioxide will be discharged into any one such fuselage compartment in accordance with established fire control procedures, or

(2) Protective breathing equipment is provided for each flight crew member on flight deck duty.

(b) The carbon dioxide concentrations at

Flying Qualities

Item	CAR ref. No.	Test description	Wt.	C. G.	Altitude	Flap	Landing gear	Engines: Operating: Prop.	Engines: Operating: Power	Engines: Operating: Cowl flap	Engines: Inoperative: Prop.	Engines: Inoperative: Thrott.	Engines: Inoperative: Cowl flap	Test	Special instrumentation
8 (a)	§ 4b.131 (a)	Long. control recovery to 1.4 V_{s_1} power on	Max. T. O. Max. land.	Most aft	Opt.	Retr. Ext.	Ext.	Max. cont.	Max. cont.	Opt.	—	—	—	Prompt recovery to 1.4 V_{s_1} should be demonstrated from any speed between V_{s_1} and 1.4 V_{s_1} when airplane is pitched down.	
(b)	§ 4b.131 (a)	Long. control recovery to 1.4 V_{s_1} power off	Max. T. O. Max. land.	Most aft	Opt.	Retr. Ext.	Ext.	Opt.	Off	Opt.	—	—	—	Same as test 8 (a).	
(c)	§ 4b.131 (b) (1)	Long. control sudden changes in flaps power off	Max. land.	Most fwd. and most aft	Opt.	Retr.	Ext.	Opt.	Off	Opt.	—	—	—	One hand controllability should be demonstrated when flaps are extended rapidly without change in trim control.	
(d)	§ 4b.131 (b) (2)	Long. control sudden changes in flaps power off	Max. land.	Most fwd. and most aft	Opt.	Ext.	Ext.	Opt.	Off	Opt.	—	—	—	One hand controllability should be demonstrated when flaps are retracted rapidly without change in trim control.	
(e)	§ 4b.131 (b) (3)	Long. control sudden changes in flaps power on	Max. land.	Most fwd. and most aft	Opt.	Ext.	Ext.	T. O.	T. O.	Opt.	—	—	—	Test 8 (d) should be repeated with T. O. power.	
(f)	§ 4b.131 (b) (4)	Long. control sudden changes in power flaps retr.	Max. land.	Most fwd. and most aft	Opt.	Retr.	Ext.	Opt.	Off	Opt.	—	—	—	One hand controllability should be demonstrated when T. O. power is applied quickly without change in trim control.	
(g)	§ 4b.131 (b) (5)	Long. control sudden changes flaps ext.	Max. land.	Most fwd. and most aft	Opt.	Ext.	Ext.	Opt.	Off	Opt.	—	—	—	Test 8 (f) should be repeated with flaps extended.	
(h)	§ 4b.131 (b) (6)	Long. control variation in airspeed	Max. land.	Most fwd	Opt.	Ext.	Ext.	Opt.	Off.	Opt.	—	—	—	One hand controllability should be demonstrated throughout speed range of 1.1 V_{s_1} to 1.7 V_{s_1} or to V_{FE} without change in trim control.	
(i)	§ 4b.131 (c)	Long. control flap retraction	Max. land.	Most fwd. and most aft	Opt.	Ext.	Ext.	Opt.	Off	Opt.	—	—	—	It should be possible to prevent altitude loss when flaps are retracted with simultaneous application of M. C. power.	
9 (a)	§ 4b.132 (a)	Directional control sudden changes in heading	Max. land.	Most aft	Opt.	Appr.	Retr.	Opt.	Power for level flight at 1.4 V_{s_1} but not more than max. cont.	Opt.	Feath.	Closed	Opt.	Satisfactory controllability should be demonstrated when sudden heading changes are executed in either direction with wings level.	Rudder force indicator if force is critical.

Flying Qualities—Continued

Item	CAR ref. No.	Test description	Wt.	C. G.	Altitude	Flap	Landing gear	Engines: Operating			Engines: Inoperative			Test	Special instrumentation
								Prop.	Power	Cowl flap	Prop.	Thrott.	Cowl flap		
9 (b)	§ 4b.132 (b)	Directional control sudden changes in heading	Max. land.	Most fwd.	Opt.	Climb	Retr.	Opt.	Power for level flight at 1.4 V_{s_1} but not more than max. cont.	Opt.	Feath.	Closed	Opt.	Test 9 (a) should be repeated with 2 crit. engs. inop.	Same as item 9 (a).
(c)	§ 4b.132 (c)	Lateral control 20° banked turns	Max. T. O.	Most aft	Opt.	Climb	Retr. and ext.	Max. cont.	Max. cont.	Opt.	Feath.	Closed	Opt.	20° banked turns with and against inoperative engine should be demonstrated from steady climb at speed of 1.4 V_{s_1}.	Bank angle indicator.
(d)	§ 4b.132 (d)	Lateral control 20° banked turns	Max. land.	Most fwd.	Opt.	Climb	Retr.	Max. cont.	Power for level flight at 1.4 V_{s_1} but not more than max. cont.	Opt.	Feath.	Closed	Opt.	Test 9 (c) should be repeated with 2 crit. engs. inop.	Same as item 9 (c).
10	§ 4b.133	Minimum control speed	Max. T. O. or less if necessary	Most aft	Opt. below T. O. power crit.	T. O.	Retr.	T. O.	T. O.	T. O.	Windmilling or any other logical position	Closed	T. O.	Minimum control speed should be determined when engine is suddenly made inoperative.	Same as item 9 (a). Bank indicator if bank is to be demonstrated.
11	§ 4b.130 § 4b.170 § 4b.171 § 4b.172 § 4b.173 § 4b.180 § 4b.181 § 4b.182	Controllability, maneuverability and stability	App.	Opt. and noted	SEE APPROPRIATE REGULATIONS									Airplane should be demonstrated for: (1) Controllability (2) Attitude during ground roll (3) nose over tendency during takeoff, landing and ground operation (4) Directional stability and control during power-off landings in cross winds and taxying (5) Water handling characteristics.	
12 (a) (b)	§ 4b.115 § 4b.123 (c)	Control Reverse thrust operation of props.													
13	§ 4b.141	Lateral and directional trim [1]	Max. T. O. and land.	Most fwd and most aft.	Opt.	Retr. and ext.	Retr. and ext.	Opt.	Power for level flight	Opt.	....	....	....	Hands-off lateral and directional trim should be demonstrated from 1.4 V_{s_1} to 90% max. speed in level flight with max. cont. power or to placard speed.	
14 (a)	§ 4b.142 (a)	Long. trim in climb	Max. T. O.	Most fwd.	Opt.	Retr. and T. O.	Retr.	Max. cont.	Max. cont.	Opt.	....	....	....	Hands-off long. trim should be demonstrated at a speed not in excess of 1.4 V_{s_1}.	
(b)	§ 4b.142 (b)	Long. trim in glide	Max. Land.	Most fwd.	Opt.	Retr. and ext.	Ext.	Wind milling	Off	Opt.	....	....	....	Hands-off long. trim should be demonstrated at a speed not in excess of 1.4 V_{s_1}.	

For footnotes, see p. 76.

(c)	§ 4b.142 (c)	Long. trim in level	Max. T. O. and land.	Most fwd and most aft.	Opt.	Retr. and ext.	Retr. and ext.	Opt.	Power for level flight	Opt.	------	------	------	Hands-off long. trim should be demonstrated from 1.4 V_{s_1} to 90% speed at max. cont. power in level flight and to V_{LE}.	
15	§ 4b.143	Long., directional and lateral trim	Max. T. O.	Most fwd	Opt.	Retr.	Retr.	Max. cont.	Max. cont.	Opt.	Feath.	Closed	Opt.	Hands-off long., directional and lateral trim should be demonstrated during climb at a speed of 1.4 V_{s_1}.	
16	§4b.144	Trim 2 engs. inop.	See note[2]	Most fwd.	Opt.	Opt.	Retr.	Max. cont.	Max. cont.	Opt.	Feath.	Closed	Opt.	Hands-off long., lateral and directional trim should be demonstrated in rectilinear flight at airspeed used in § 4b.121.	
17	§4b. 152	Static long. stability landing power-off	Max. land.	Most fwd and most aft	Opt.	Ext.	Ext.	Windmilling	Power-off	Opt.	------	------	------	Static long. stability should be demonstrated from 1.1 V_{s_1} to 1.8 V_{s_1} or to placard speed with airplane trimmed at 1.4 V_{s_1}.	Elevator control force indicator.
18	§ 4b.153	Static long. stability approach	Max. land.	Max. aft	Opt.	Appr.	Retr.	Power for level flight at 1.4 V_{s_1}		Appr.	------	------	------	Same as test 17 ------	Same as item 17.
19	§ 4b.154	Static long. stability climb	Max. T. O.	Most aft	Opt.	Retr.	Retr.	75% max. cont.		Opt.	------	------	------	Static long. stability should be demonstrated from 85% to 115% of V_{trim} when airplane is trimmed at best R/C speed except that trim speed need not be less than 1.4 V_{s_1}.	Same as item 17.
20 (a)	§ 4b.155 (a)	Static long. stability cruise	Max. T. O.	Most aft	Opt.	Retr.	Retr.	75% max. cont.		Opt.	------	------	------	Static long. stability should be demonstrated from 1.3 V_{s_1} to 1.8 V_{s_1} or to V_{NE} whichever is less, with airplane trimmed at speed for level flight with 75% M. C. power.	Same as item 17.
(b)	§ 4b.155 (b)	Static long. stability cruise	Max. T. O.	Most aft	Opt.	Retr.	Ext.	75% max. cont.		Opt.	------	------	------	Same as test 20 (a) but speed should be in excess of level flight trim or gear down placard speed.	
21	§ 4b.156	Dynamic long. stability	OPTIONAL											Damping of any short period oscillations between stalling speed and max. permissible speed should be demonstrated with controls free and in a fixed position.	
22 (a)	§ 4b.157 (a)	Static directional stability	Max. T. O. Max. land	Most aft	Opt.	Retr. Ext.	Retr. Ext.	See § 4b.157		Opt.	------	------	------	Recovery from skid with rudder free should be demonstrated.	
(b)	§ 4b.157 (b)	Static lateral stability	Max. T. O.	Most aft	Opt.	Retr.	Retr. Ext.	------		Opt.	------	------	------	Tendency of wing to raise in recovery from turn should be demonstrated.	Rudder force indicator.
(c)	§ 4b.157 (c)	Static directional and lateral stability	Max. T. O. Max. land	Most aft	Opt.	Retr. Ext.	Retr. Ext.	------		Opt.	------	------	------	Proportionality of aileron and rudder deflections and forces during sideslip should be demonstrated.	
23	§4b.158	Dynamic directional and lateral stability	Max. T. O. and land	Most aft	Opt.	Retr. and ext.	Retr. and ext.	Opt.	Opt.	Opt.	------	------	------	Damping of any short period oscillations should be demonstrated with controls free and fixed at all speeds.	

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Item	CAR ref. No.	Test description	Wt.	C. G.	Altitude	Flap	Landing gear	Engines: Operating: Prop.	Engines: Operating: Power	Engines: Operating: Cowl flap	Engines: Inoperative: Prop.	Engines: Inoperative: Thrott.	Engines: Inoperative: Cowl flap	Test	Special instrumentation
24 (a)	§4b.160	Stalls symmetrical power straight flight	Land Land Land Land Land Land Land Land T. O. T. O. T. O. T. O.	Fwd Fwd Aft Aft Aft Aft Aft Aft Aft Aft Aft Aft	Opt.	Appr. Land Appr. Land Appr. Appr. Land Land Retr. T. O. Retr. T. O.	Ext. Ext. Ext. Ext. Retr. Ext. Retr. Ext. Ext. Ext. Ext. Ext.	Opt.	On On Off Off On On On On Off Off On On	Opt.	----------	----------	----------	See §4b.160 (c) (1)----------	Means for continuous recording of angle-of-attack indicator, accelerometer; swivel static and shielded total pressure heads; altimeter; pitch and bank angle indicator; accelerometer; elevator position and force indicator; aileron and rudder position indicator.
(b)		Stalls symmetrical power turns	T. O. T. O. Land Land	Aft Aft Aft Aft	Opt.	Retr. Retr. Land Land	Retr. Retr. Ext. Ext.	Opt.	Off On Off On	Opt.	----------	----------	----------	Prompt recovery and regain of control with normal piloting skill should be demonstrated in left and right turns up to 30 degrees of bank.	
25	§4b.161	Stalls asymmetrical power	Max. T. O.	Aft	Opt.	Retr.	Retr.	75% maximum continuous power		Opt.	Opt.	Closed	Opt.	Safe recovery from stall without excessive loss of altitude should be demonstrated. Operating engines may be throttled back during recovery.	Rudder control force indicator if force is critical.
26	§4b.173	Controllability T. O. and land. in cross wind	Max. T. O. Max. land	Most aft	Opt.	T. O. Ext.	Ext.	Takeoff and power off		Opt.	----------	----------	----------	Takeoffs and landings in cross winds should be demonstrated.	Wind velocity and direction indicator.
27	§4b.190	Flutter and vibration	Max. T. O. Max. land	Most aft		Retr. Ext.	Retr. Ext.	Cruise power		Opt.	----------	----------	----------	The airplane should be tested from V_{s_1} to V_D or to placard speed, gear up and down, flaps up, T. O. approach and landing.	
28	§4b.324	Wing flap interconnection					REQUIREMENTS SHOULD BE SET UP FOR INDIVIDUAL CASES								

[1] Additional lateral and directional trim should be demonstrated in other configurations in conjunction with tests in §4b.150.
[2] Weight at which climb is equal to at least 0.01 $V_{s_0}{}^2$ at 5,000 feet altitude.

Powerplant Tests

Item	CAR ref. No.	Test description	Wt.	C. G.	Altitude	Flap	Landing gear	Engines: Operating: Prop.	Engines: Operating: Power	Engines: Operating: Cowl flap	Engines: Inoperative: Prop.	Engines: Inoperative: Thrott.	Engines: Inoperative: Cowl flap	Test	Special instrumentation
29 (a)	§ 4b.400	Powerplant operation	----------	----------	----------	Opt.	Opt.	----------	----------	----------	----------	----------	----------	Powerplant and propeller operation should be observed for satisfactory operation during the flight test program.	
(b)	§ 4b.400	Propeller operation	----------	----------	----------	Opt.	Opt.								
30 (a)	§ 4b.416 (b) (1)	Unusable fuel level flight	Opt.	Opt.	Opt.	Retr.	Retr.	See test		Opt.	----------	----------	----------	Unusable fuel should be determined in level flight at power required for V_c or at max. cont. power whichever is less. Fuel tank should be turned off when fuel pressure decreases, or the engine malfunctions.	
(b)	§ 4b.416 (b) (2)	Unusable fuel climb	Not more than max. land.	Opt.	Opt.	T. O.	Retr.	T. O.	T. O.	Opt.	----------	----------	----------	Unusable fuel should be determined during climb at V_2 speed. Fuel tank should be turned off when fuel pressure decreases or engine malfunctions.	
(c)	§ 4b.416 (b) (3)	Unusable fuel glide to climb	Land.	Opt.	Opt.	Ext.	Ext.	See test		Opt.	----------	----------	----------	Unusable fuel should be determined during rapid application of max. cont. power and subsequent transition to climb at speed V_2 with retraction of flaps from a power off glide at 1.3 V_{s0} flaps and gear ext. Fuel tank should be turned off when fuel pressure decreases or the engine malfunctions.	
(d)	§ 4b.416 (c)	Fuel Pressure	----------	----------	----------	Opt.	Opt.	----------	----------	----------	----------	----------	----------	Ability to regain full fuel pressure on an engine should be demonstrated when engine runs out of fuel from any tank which engine can be fed and when engine is then switched to any full tank.	
(e)	§ 4b.416 (d)	Unusable fuel in tanks not used in T. O. and landing	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	Fuel runout tests on ground or in flight should be conducted as required in § 4b.416 (b) (1).	
31	§ 4b.417	Fuel system hot weather operation	See test	Opt.	See test	Retr.	Retr.	Max. T. O. and max. cont.		----------	----------	----------	----------	Vapor lock or occurrence of any other malfunctioning should be determined when airplane is operated with fuel 110° F at climb speed which should not exceed that permitting compliance with climb requirement of § 4b.119 (a) to the max. operating alt. selected by applicant. Airplane wt. should correspond to operation with full fuel tanks, minimum crew, and ballast to keep airplane within c. g. limits. (This test may be conducted on ground.)	

Powerplant Tests—Continued

Item	CAR ref. No.	Test description	Wt.	C. G.	Altitude	Flap	Landing gear	Engines						Test	Special instrumentation
								Operating			Inoperative				
								Prop.	Power	Cowl flap	Prop.	Thrott.	Cowl flap		
32	§ 4b.430	Fuel pump	Opt.	Opt.	6000	Opt.	Opt.	Power to maintain level flight		Opt.	--------	--------	--------	Engine operation with fuel at 110°F. using engine-driven fuel pumps alone. This may be a ground test.	
33	§ 4b.452 § 4b.440 (e) § 4b.465	Cooling Climb	Max. T. O.	Opt.	See Test	Opt.	Opt.	Max. Cont.	Max. Cont.	CAA hot day cooling position	Feath.	Closed	Opt.	After temperatures are stabilized in level flight, cooling climb should be started at or below the lower of the two altitudes specified in requirement and continued until 5 minutes after peak climb temperatures have been noted or to max. operating alt.	Calibrated temperature indicators for critical head and base, oil inlet, coolant outlet, etc.
34	§ 4b.453 § 4b.440 (e) § 4b.465	Cooling Takeoff	Max. T. O.	Opt.	Lowest practicable	Opt.	Opt.	T. O.	T. O.	CAA hot day cooling	Feath.	Closed	Opt.	After temperatures are stabilized in level flight at 75% max. cont. power (all engines operating) using normal cowl flaps and shutter settings, one engine should be feathered and climb started at lowest practicable altitude and continued for the same time interval as takeoff power is used during the determination of the takeoff flight path, the power then being reduced to max. cont. and the climb continued until at least 5 minutes after occurrence of the peak temperature.	Same as item 33.
35	§ 4b.454	Cooling Seaplane operation	Max. T. O.	Opt.	--------	Opt.	--------	Opt.	Sufficient for test air speed	Opt.	--------	--------	--------	Seaplane should be taxied for 10 mins. at 5 m. p. h. above the step speed after temperatures are stabilized.	Same as item 33.
36	§ 4b.461	Carburetor air heat rise	Opt.	Opt.	Opt.	Opt.	Opt.	60% max. cont. power		Opt.	--------	--------	--------	Airplane should be stabilized in flight with full cold carburetor. Carburetor preheat should be applied slowly and maintained until carburetor air temperature has stabilized. Tests should be conducted at two different ambient air temperatures unless one test is conducted at temperature of 30° F.	

Functional and Miscellaneous Tests

Item	CAR ref. No.	Test description	Wt.	C. G.	Altitude	Flap	Landing gear	Engines: Operating: Prop.	Engines: Operating: Power	Engines: Operating: Cowl flap	Engines: Inoperative: Prop.	Engines: Inoperative: Thrott.	Engines: Inoperative: Cowl flap	Test	Special instrumentation
37 (a)	§ 4b.334 § 4b.116 (b)	Land. gear retracting mechanism operation and time to retract.	Opt.	Opt.	----------	----------	----------	----------	----------	----------	----------	----------	----------	Landing gear retraction and extension at 1.6 V_{s1} and time to retract at V_2 speed should be demonstrated. Structure should be substantiated at 0.67 Vc.	
(b)	§ 4b.334 (c)	Emergency land. gear mechanism operation.	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	Satisfactory gear extension by use of emergency system should be demonstrated.	
38	§ 4b.337	Brakes	Max. land.	Most fwd.	----------	----------	----------	----------	----------	----------	----------	----------	----------	Braking deceleration should be demonstrated to be at least 50% of that obtained in § 4b.122 with loss of any single source of brake operating energy supply.	
39	§ 4b.116 (c) § 4b.401 (c)	Propeller time to feather	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	The time required for the propeller to change from windmilling position to feather position should be determined at V_2 speed. Feathering at max. operating altitude should also be demonstrated.	
40 (a)	§ 4b.437 (a) (1)	Fuel jettisoning power-off glide.	Max. T. O.	Opt.	Opt.	Retr. or desired approved position.	Retr. or ext.	Windmilling.	Off	Opt.	----------	----------	----------	The time required to jettison fuel from tanks and the path of jettisoned fuel as to whether it impinges on any part of the airplane during or after jettisoning should be determined.	
(b)	§ 4b.437 (a) (2)	Fuel jettisoning climb.	Max. T. O.	Opt.	Opt.	Retr. or desired approved position.	Retr. or ext.	Max. cont.	Max. cont.	Opt.	Feath.	Closed	Closed	Same as test 40 (a) during climb with critical eng. inoperative.	
(c)	§ 4b.437 (a) (3)	Fuel jettisoning level flight	Max. T. O.	Opt.	Opt.	Retr. or desired approved position	Retr. or ext.	----------	Opt.	----------	----------	----------	----------	Same as test 40 (a) during level flight.	
41 (a)	§ 4b.467	Exhaust system carbon monoxide	Opt.	Opt.	----------	----------	----------	----------	----------	----------	----------	----------	----------	Carbon monoxide concentration should be determined in personnel compartments during T. O., climb, level flight, approach or landing flight and during heater and cabin supercharger operation.	Carbon monoxide detection indicator.

Functional and Miscellaneous Tests—Continued

Item	CAR ref. No.	Test description	Wt.	C. G.	Altitude	Flap	Landing gear	Engines: Operating: Prop.	Engines: Operating: Power	Engines: Operating: Cowl flap	Engines: Inoperative: Prop.	Engines: Inoperative: Thrott.	Engines: Inoperative: Cowl flap	Test	Special instrumentation
41 (b)	§ 4b.467 (a) (5)	Visibility.	Opt.	Opt.	------	------	------	------	------	------	------	------	------	The effect of any exhaust gas discharge on pilot visibility at night should be determined.	
42	§ 4b.612 (b)	Altimeter calibration	Between max. land and max. T. O.	Opt.	Opt.	Retr.	Retr. Ext.	Opt.	Opt.	Opt.	------	------	------	If altimeter and airspeed use the same static vent, theoretical calibration from airspeed calibration should be determined and checked by flights at a precise elevation at various speeds.	Instrumentation for accurately determining airplane elevation.
43	§ 4b.640	Pneumatic boots	Opt.	Opt.	------	------	------	------	------	------	------	------	------	Operation of pneumatic boots should be checked in flight from just above stall the buffeting speed to 1.6 V_{s_1} and at power off stall.	
44	§ 4b.642	Flare operation	Opt.	Opt.	------	------	------	------	------	------	------	------	------	Flight demonstration should be conducted to determine that flare ejection can be accomplished without danger to the airplane or its occupants.	

45 (a) § 4b.337 (b) Brake control forces and operation
(b) § 4b.337 (c) Parking brake
(c) § 4b.350 (g) Noise level
(d) § 4b.351 (a) Pilot compartment vision
(e) § 4b.351 (b) Windshield wiper and de-icer operation
(f) § 4b.353 Cockpit controls
(g) § 4b.376 Cabin pressurization
(h) § 4b.384 Cargo and baggage compartment fire precaution
(i) § 4b.404 Propeller pitch and speed limitation
(j) § 4b.406 Propeller de-icing fluid
(k) § 4b.418 Fuel overflow—interconnected tanks
(l) § 4b.426 Fuel overflow and syphoning—fuel tank vents
(m) § 4b.449 Propeller feathering—trapped oil supply
(n) § 4b.611 Visibility of instrument installation
(o) § 4b.630 Instrument lights
(p) § 4b.631 Landing lights

Appendix B

Suggested Flight Programs for Approval of Changes in Airplane Configuration

The following assumes that an airplane has been type certificated in the transport category, and that a change is made affecting the operating characteristics of the airplane. Suggested general flight programs are given for common type of changes. This is to be used as a guide only since individual cases may require additional or fewer tests than those listed.

1. Tests Affected by *Change in Propeller*

Items	*Test Description*
5	Accelerate to V_1 cut one engine and continue acceleration to V_2
6(b)	Climb—second T. O. segment
6(e)	Climb—en route—all engines
6(g)	Climb—en route—two engines inoperative
6(h)	Climb—approach
6(i)	Climb—landing
10	Minimum control speed
29(b)	Propeller operation
33, 34 and 35	Cooling tests
36	Time to feather propeller
45(i)	Propeller pitch and speed limitations

2. Tests Affected by *Change in Power Rating*

Items	*Test Description*
2 (a)	Critical altitude—takeoff power
2 (b)	Critical altitude—max. cont. power
5	Accelerate to V_1 cut one engine and continue acceleration to V_2
6 (b)	Climb—2d T. O. segment
6 (e)	Climb—en route—all engines
6 (g)	Climbs—two engines inoperative
6 (h)	Climb—approach
6 (i)	Climb—landing
8 (f)	Control—sudden changes in power
9 (c)	Control 20° banked turns
10	Minimum control speed
15	Trim 2 engines inoperative
30	Cooling climb—max. cont.
31	Cooling—takeoff

3. Tests Affected by *Addition of a Major Drag Item* (Such as External Tank)

Items	*Test Description*
3	Stalling speeds
5	Accelerate to V_1 cut engine and continue acceleration to V_2
6 (a)	Climb—takeoff first segment
6 (e)	Climb—en route—all engines
6 (g)	Climb—en route—2 engines inoperative
6 (h)	Climb—approach
6 (i)	Climb—landing
8 (h)	Control—variation in airspeed
27	Flutter and vibration

4. Tests Affected by *Change in Engines*

Items	*Test Description*
2 (a)	Critical altitude—T. O. power
2 (b)	Critical altitude—max. cont. power
5	Accelerate to V_1, cut one engine and continue acceleration to V_2
6 (b)	Climb, 2d T. O. segment
6 (e)	Climb—en route—all engines
6 (g)	Climb—two engines inoperative
6 (h)	Climb—approach
6 (i)	Climb—landing
8 (f)	Control—sudden changes in power
9 (c)	Control 20° banked turns
10	Minimum control speed
16	Trim 2 engines inoperative
33	Cooling climb—max. cont. power
34	Cooling—takeoff power
36	Carburetor air heat rise

Appendix C

A General Order of Testing

Order	*Test Description*	*Item*
1.	Airspeed and altimeter calibrations	1, 42
2.	Stall speeds	3
	Engine calibration	2
3.	Minimum control speed	10
4.	Engine cooling	33, 34, 35
5.	Ground speed calibration, accelerate and stop, accelerate, landing tests, and reverse thrust propeller control	1, 4, 5, 7, 12
6.	Climb tests	6 (a) through 6 (i)
7.	Fuel system operation and carburetor air heat rise	30 (a) through 30 (e), 31, 32, 36
8.	Control tests	8 (a) through 8 (i), 9 (a) through 9 (d), 11, 26
9.	Stall characteristics	24 (a), 24 (b), 25

10. Trim characteristics and static longitudinal, directional and lateral stability — 13, 14 (a) through 14 (c), 15, 16, 17, 18, 19, 20 (a), 20 (b), 21, 22 (a) through 22 (c), 23, 28
11. Flutter and vibration — 27
12. Fuel jettisoning — 40 (a) through 40 (c)
13. Exhaust system, flare operation, pneumatic boots, landing gear, brakes, propeller feathering, and miscellaneous functional — 41 (a), 41 (b), 44, 43, 37 (a), 37 (b), 38, 39, 45

Appendix D

Transport Category (Part 4b) Flight Tests Grouped According to Weight and C. G. Conditions

DEFINITIONS

1. Takeoff weight—The maximum takeoff weight at sea level.
2. Landing weight—The maximum landing weight at sea level.
3. Low weight—A specific weight either lower than maximum takeoff or maximum landing.
4. Optional weight—Any weight that the manufacturer elects to use.
5. Appropriate weight—Appropriate to the airplane configuration; i. e., takeoff or landing.
6. Forward c. g.—The maximum forward center of gravity for which approval is desired. If the manufacturer desires to obtain approval for center of gravity limits varying with weight, he may (1) make the test at the nominal weight at the most forward c. g. regardless of weight, or (2) make *the critical tests at both the nominal weight and its forward center of* gravity limit and at the weight which gives the most forward center of gravity.
7. Aft c. g.—The maximum aft center of gravity for which approval is desired. See 5.
8. Optional c. g.—Any center of gravity that the manufacturer elects to use.

WEIGHTS

The test numbers listed below correspond to the item numbers in Appendix A.

1. Takeoff weight
   a. Forward c. g.—4, 5, 13, 14 (a), 14 (c), 15
   b. Aft c. g.—8 (a), 8 (b), 9 (c), 10, 13, 14 (c), 19, 20 (a), 20 (b), 22 (a) through 22 (c), 23, 24, 25, 26, 27
   c. Optional c. g.—6 (a) through 6 (f), 34, 35, 40 (a) through 40 (c)
2. Landing weight
   a. Forward c. g.—3, 7, 8 (c) through 8 (i), 9 (b), 9 (d), 13, 14 (b), 14 (c), 16, 17, 38
   b. Aft c. g.—8 (a), 8 (b), 9 (a), 13, 14 (c), 17, 18, 22 (a) through 22 (c), 23, 24, 26
   c. Optional c. g.—6 (h), 6 (i), 8 (c) through 8 (i), 30 (c)

3. Low weight
   a. Forward c. g.—4, 5, 7 [1]
   b. Aft c. g.—None
   c. Optional c. g.—6 (a) through 6 (f), 6 (g) (2 wgts.), 6 (h), 6 (i), 30 (b)
4. Optional weight
   a. Forward c. g.—None
   b. Aft c. g.—None
   c. Optional c. g.—1, 2 (a), 2 (b), 21, 27, 28, 29 (a), 29 (b), 30 (a), 30 (d), 30 (e), 32, 36, 37 (a), 37 (b), 39, 41 (a), 41 (b), 42, 43

[1] Most critical c. g. should be used if demonstrations are to be made using reverse thrust.

Appendix E

Instrumentation Summary

1. Performance Tests

Item	*Test Description*	*Special Instrumentation*
1	Airspeed calibration.	Reference airspeed system.
	Ground speed calibration.	May be conducted in conjunction with instrumentation for item 4.
2	Engine calibration.	Humidity indicator.
3	Stalling speeds.	Reference airspeed system, instrument photo-recorder
4	Accel. to V_1 and stop.	Graphically recording vertical and horizontal distance-time instrumentation, wind velocity and direction meteorological instrumentation, humidity indicator.
5	Accel. to V_2.	Same as for item 4.
6 (a) thru 6 (i)	Climbs.	Humidity indicator.
7	Landings.	Same as for item 4.

2. Flying Qualities

Item	*Test Description*	*Special Instrumentation*
9 (a) and 9 (b)	Control—sudden changes in heading.	Rudder force indicator.
10	Minimum control speed.	Rudder force indicator.
17 thru 20 (b)	Static longitudinal stability.	Elevator stick force indicator.
22 (a), 22 (b), and 22 (c)	Directional and lateral stability.	Rudder control force indicator.
24	Stalls.	Angle-of-attack indicator, accelerometer; swivel static and shielded total pressure head; altimeter; pitch and bank angle indicator; elevator position and force indicator; aileron and rudder position indicator.

Item	Test Description	Special Instrumentation
25	Stalls—one engine out.	Rudder control force indicator required only when rudder control forces are critical.
26	Control—takeoff and landing in crosswind.	Wind velocity and direction measurement instrumentation.

3. Power Plant Tests

Item	Test Description	Special Instrumentation
33, 34, and 35	Cooling tests.	Temperature indicators for critical head, base, oil inlet, coolant temperatures.
36	Carburetor air heat rise.	Temperature indicator for carburetor.

4. Functional and Miscellaneous Tests

Item	Test Description	Special Instrumentation
41 (a)	Exhaust system—carbon monoxide.	Carbon monoxide detection indicator.
42	Altimeter calibration.	Instrument for precisely determining airplane elevation.

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