SPECIFICATION FOR PILOT'S OPERATING HANDBOOK

GAMA Specification No. 1
Issued: February 15, 1975
Revised: October 18, 1996, Revision No. 2

Limited Review

for commentary and teaching purposes

Including Recaps of Pitot-Static System, Calibrated and Indicated Airspeeds
and Minimum Control Speed

Harry Horlings

Pilot and Flight Test Engineer, ret.

Avio*Consult*
Independent Aircraft Expert and Consultant

– Committed to Improve Aviation Safety –

Copyright © 2026, Avio*Consult*

SPECIFICATION FOR PILOT'S OPERATING HANDBOOK, GAMA Specification No. 1 – Limited Review

Copyright © 2026, Avio*Consult*, all rights reserved.

This review is written by Harry Horlings, Lt-Col RNLAF ret., BSc, graduate Flight Test Engineer of the USAF Test Pilot School, class 85A, former chief experimental flight-test RNLAF,
e-mail: horlings@avioconsult.com, website: https://www.avioconsult.com.

Harry Horlings has been appointed Officer in the Order of Orange-Nassau by the King of the Netherlands in 2022 for rendering outstanding service of national and international importance concerning airplane accident prevention and investigations.

The copyright of this paper belongs to and remains with Avio*Consult* unless specifically stated otherwise.

By accepting this paper, the recipient agrees that neither this paper nor the information disclosed herein nor any part thereof shall be reproduced or transferred to other documents or used by or disclosed to others for any purpose except as specifically authorized in writing by Avio*Consult*.

Avio*Consult* has written this paper in good faith, but no representation is made or guarantee given (either express or implied) as to the completeness of the information it contains.

By accepting this paper, the recipient agrees that Avio*Consult* will not be liable for any direct or indirect loss arising from the use of the information and materiel contained in this paper.

General conditions apply, and are made available upon request

Date of this version: 2026-02-14.

It is recommended to download the most recent version with working links from website:
www.avioconsult.com/downloads.htm (#14).

CONTENTS

1. Introduction 4
2. Preface of GAMA Specification No. 1 6
3. Airspeeds Explained 7
4. Review of Section 1. General 24
5. Review of Section 2. Limitations 27
6. Review of Section 3. Emergency Procedures 29
7. Review of Section 3A. Abnormal Procedures 30
8. Review of Section 4. Normal Procedures 31
9. Review of Section 5. Performance 31
10. Review of Section 10. Safety and Operational Tips (Optional) 33
11. Conclusions of the Review of GAMA Specification No. 1 35
12. Recommendations 38
List of Abbreviations and Symbols 40

ATTACHMENT

First 95 pages of GAMA Specification No. 1, Revision No. 2, October 18, 1996.

LIST OF FIGURES

Figure 1. True Airspeed (TAS, V_t) equation. 7
Figure 2. A common pitot-static system and its errors; from Calibrated Airspeed (CAS) in undisturbed airstream to Indicated Airspeed (IAS) on the Airspeed Indicator (ASI). 8
Figure 3. Calibrated Airspeed (CAS, V_c) equation 8
Figure 4. Lateral-Directional forces and moments in body axis coordinate system, OEI, wings level, straight flight. 18
Figure 5. Lateral-Directional forces and moments in body axis coordinate system, OEI, bank angle 5° into good engine, steady straight flight. 18
Figure 6. Effect of bank angle on V_{MCA} and on rudder, aileron, and sideslip angles during equilibrium flight at maximum thrust, for a sample airplane. 20
Figure 7. Effect of bank angle and weight on $V_{MC(A)}$. 20

1. Introduction

1.1. During the past 25 years, more than 520 engine failure-related accidents with small and big multi-engine airplanes were reported on the Internet alone, causing more than 4,150 casualties; these numbers are still growing. Airplanes are designed and thoroughly flight-tested to be able to continue to fly safely following the failure of one or two engines, so why do such accidents happen? Avio*Consult* started reviewing Accident Investigation Reports, Airplane Flight Manuals (AFM), Pilot's Operating Handbooks (POH) and multi-engine rating courses 20 years ago. It did not take long to conclude that there is an accident-causing knowledge gap about performance and controllability of multi-engine airplanes while an engine is inoperative between (airline) pilots, including writers of POH/AFM and training manuals, and approving authorities on one side, and airplane design engineers of manufacturers, including experimental test pilots on the other side.
Multi-engine rated pilots learn about the minimum control speed (V_{MC} or V_{MCA}) of their airplane, but are regrettably neither made aware anymore of the real value of the V_{MCA} that is published as one of the airspeed limitations in the Airplane Flight Manual (AFM), nor of the associated maneuver limitations that apply for this V_{MCA} to be valid, but which must be observed to avoid losing control when one engine is indeed fails or is inoperative and high thrust is set on the remaining engine(s). V_{MCA} is already used during the design phase of the airplane for sizing the aerodynamic control surfaces rudder and ailerons, and is verified/determined during experimental flight-tests by experimental test pilots, graduates of a test pilot school.
The many fatal accidents mentioned above are the consequence of inappropriate guidance in multi-engine rating learning manuals, including those of the FAA, and in POHs /AFMs for preventing the loss of control in case an engine fails, or is inoperative. Proper knowledge on this subject obviously got lost or forgotten during the past 50 years.

1.2. While reviewing a *Pilot Operating Handbook and Airplane Flight Manual* of a Viking DHC-6 following a fatal accident in Thailand in June 2025, the existence of *General Aviation Manufacturers Association (GAMA) Specification No.1*[1] was noticed, revealing the source of improper use of airspeeds and of procedures for flight with a failing or inoperative engine in Airplane Flight Manuals and/or Pilot's Operating Handbooks of Beechcraft, Cessna, DHC, Diamond, Piper, and other Part 23 and even Part 25 multi-engine airplane manufacturers.
The provided guidance in GAMA Specification No. 1 on several subjects is neither in agreement with airplane design methods as taught at universities[2], nor with Federal Aviation Regulation 14 CFR FAR 23[3] or equivalent, and nor with the FAA Flight Test Guide in Advisory Circular AC 23-8C[4] either, making a critical review of the GAMA Specification No. 1 an indispensable obligation of a flight-test expert who has become aware of improper guidance by manufacturers, as contribution to preventing fatal accidents in the future.

1.3. The author of this limited review is graduate Flight Test Engineer of the USAF Test Pilot School, Edwards AFB, CA (1985). TPSs were founded 80 years ago after many experienced pilots crashed during flight-testing prototypes of new airplanes due to the lack of engineering knowledge. The very few Test Pilot Schools around the globe provide the highest level of flight-test training required to conduct experimental flight tests in or with any aircraft. The entrance level was an MSc degree in engineering or a BSc and an entrance exam. Test Pilot Schools teach aircraft performance, flying qualities, and airborne systems. During the one-year course, students receive in 50% of the time theory on the subjects mentioned and conduct some 120 flight hours of flight-test training and flight-test experience in 24 different types of airplanes: gliders, single-, twin- and 4-engine propeller and turbojet airplanes, fighter jets, helicopters, and simulators. They

[1] GAMA Specification No. 1, Specification for Pilot's Operating Handbook. https://gama.aero/documents/gama-specification-1-specification-for-pilots-operating-handbook-version-2-0/ (Attached).
[2] Stability and Control during Steady Straight Flight, Airplane Design Part VII, Dr. Jan Roskam, DAR Corporation, Kansas: https://shop.darcorp.com/index.php?route=product/category&path=60
[3] Code of Federal Regulations, Title 14, Chapter I, FAR 23, 1–1–10 Edition was used in this review. Link to FAR 23 2017: https://www.ecfr.gov/on/2017-01-03/title-14/chapter-I/subchapter-C/part-23/subpart-B.

Copyright © 2026, AvioConsult. All Rights Reserved

must pass 32 exams, write 32 reports, and undergo frequent test rides. Calibrating pitot-static systems, and flying qualities testing and evaluating of multi-engine airplanes while half of the number of engines are made inoperative, and determining the Minimum Control Speed (V_{MC} or V_{MCA}) is part of the curriculum.
The flight-test techniques that test pilots use are also described in an FAA Flight Test Guide[4]. The Flying Qualities textbook of the USAF Test Pilot School, which includes the explanation of the controllability of multi-engine airplanes when an engine is inoperative, i.e. when flying on asymmetrical power, can be downloaded in two parts from the US Archives[5].

1.4. To again increase the level of knowledge about flight with an inoperative engine, Avio*Consult* published several reviews and accident analyses, wrote several papers and courses, and published these on the Downloads and Accidents pages of its website[6] and in aviation magazines. A video lecture *"The real Value of V_{MCA}"* with the subtitle *"How to prevent a dead engine from turning into a killing engine"* was uploaded on YouTube[7]. Papers were also presented during seminars of the European Chapter of the Flight Safety Foundation[8], the Safety Forum in Brussels[9], ALPA and other organizations, such as FAA Engine and Propeller Directorate, Luftfahrt Bundes Amt, and Delft University. Letters were written to FAA, NTSB (Dr. Earl F. Weener), ATSB and manufacturers with the recommendation to improve their investigations and Flying Handbooks, but these organizations did not respond, change anything, and obviously did not appreciate the competency of a Test Pilot School graduate either.
Dr. Weener quoted Douglas Adams in a video on the subject loss of control during takeoff and landing: *"Human beings, who are almost unique in having ability to learn from the experience of others, are also remarkable for their apparent disinclination to do so"*.
Most pilots explain the controllability of an airplane with an inoperative engine not correctly, because of unawareness of all the forces and moments acting on an engine-out airplane. Improper and short falling manuals did put the mishap pilots on the wrong foot. Accident investigating organizations do not conclude the real cause of controllability problems which are all reasons why accidents continue to occur; aviation is drifting into failure due to knowledge poverty. Therefore, Avio*Consult* continues its unsolicited work and wrote this review.

1.5. This review presents engineering and experimental flight-test-based facts, not opinions, and is not to apportion personal blame or liability, but is written to alert, make aware, teach, and learn from, which is necessary because proper knowledge obviously just faded away, and fatal accidents with multi-engine airplanes continue to occur every month. Explanations as well as some recommendations for improvement are included to bring a stop to the unnecessary accidents and associated fatalities.
Pilots have the right to be able to use the limiting and operational speeds as intended for maintaining flight safety, and to know and understand how to prevent a dead engine from turning into a killing engine. Pilots have the right to be furnished with excellent POHs, AFMs, and training manuals. It is the duty and responsibility of the members of GAMA to provide such manuals. This review is written to stimulate this effort by contributing to improving airplane operating, flight and training manuals.

[4] FAA Flight Test Guide, AC 23-8C: http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_23-8C.pdf.
[5] Flying Qualities Textbook, USAF Test Pilot School, Volume II, Part 1, 1986, https://ia800107.us.archive.org/32/items/DTIC_ADA170959/DTIC_ADA170959.pdf,
Flying Qualities Textbook, USAF Test Pilot School, Volume II, Part 2, 1986 (Chapter 11, Asymmetrical power), https://ia801001.us.archive.org/17/items/DTIC_ADA170960/DTIC_ADA170960.pdf.
[6] Website Avio*Consult*: https://www.avioconsult.com.
[7] Harry Horlings, Avio*Consult*, video lecture: *"The real value of the minimum control speed"*, https://youtu.be/Wbu6X0hSnBY.
[8] Harry Horlings, Avio*Consult*, *"Staying Alive with a Dead Engine"*. Proceedings – European Aviation Safety Seminar (EASS), Athens, Greece, March 13 – 15, 2006.
[9] Harry Horlings, Avio*Consult*, *"Safety Critical Procedure Development requires high level multi-disciplinary knowledge"*, https://skybrary.aero/sites/default/files/bookshelf/4665.pdf. PPT with working animations: https://www.avioconsult.com/downloads/Safety Forum slides AvioConsult June 2019 - video links.ppsm.

2. Preface of GAMA Specification No. 1

2.1. In the preface, the limitation of Specification No. 1 is stated: *"Pilots Operating Handbooks prepared in accordance with "GAMA Specification No. 1", as revised through Revision No. 2, dated October 18, 1996, are appropriate for showing compliance with CAR 3, Paragraph 3.777, and FAR 23, Paragraph 23.1581 on airplanes having a certification basis including FAR 23 through Amendment 23-44 except Commuter Category"*.

2.1.1. Hence, the Specification applies to small twins with seating configuration of nine or less, the normal and utility categories. The Specification is however also used by manufacturers of SFAR 23 airplanes carrying more than 10 occupants and FAR 23 commuter class airplanes with a seating configuration up to 19 passengers, like the Viking DHC-6 Twin Otter and the Beechcraft 1900. This review therefore includes relevant comments for these airplane categories as well.

2.2. The Preface continues with: *"This Specification was developed by representatives of member companies of the General Aviation Manufacturers Association for use in preparing Pilot's Operating Handbooks that:*

a. Are of maximum usefulness as an operating reference book for pilots;

b. Meet government regulatory requirements where applicable; and

c. *Meet industry standards for scope of material, arrangement, nomenclature, and definitions."*

2.2.1. This review will show that Specification No.1 is not of maximum usefulness as a guide to operating manuals for pilots, and does not meet government regulatory requirements. The information needed for pilots to operate an airplane in a safe manner is not provided in the Specification. The Specification does not contribute to preventing accidents.

2.3. In the first paragraph on page v of the Preface is stated: *"Calibrated Airspeed (CAS) is to be used only as necessary to comply with any applicable requirements of the certificating authority as the pilot works exclusively with Indicated Airspeed (IAS)"*.

2.3.1. The pilot indeed can only read the Indicated Airspeed (IAS) from the Airspeed Indicator in the cockpit, but must also work with the limiting speeds and performance data in the POH/AFM which are (originally) provided as Calibrated Airspeeds (CAS), as is determined in SFAR 23.5(b) for operations under Part 135 for takeoff speeds and the speeds used to calculate these speeds (§ 5(b)), such as V_S and V_{MC}, and is determined in FAR 23.51, and then calculate from CAS the corresponding IAS by adding the pitot-static system position error and the Airspeed Indicator (ASI) instrument error for the flying task, or vice versa. As will be explained in this review, working exclusively with Indicated Airspeeds requires a separate POH/AFM for each Airspeed Indicator (serial number) and each individual airplane of a series of airplanes (each tail number), which also must be approved by the authorities, because the limiting and operational speeds are in the FAA approved parts of the manuals.
This Preface-statement is incorrect and is not true, is neither in agreement with the way these airspeeds are defined in FAR 23, nor as used by airplane design engineers, nor as used during experimental flight testing, and nor are taught at universities and Test Pilot Schools. It is obviously written by pilots who do not have a higher-level of knowledge of pitot-static systems and airspeeds.
The writers of the Specification and the approving authorities seem to struggle with understanding why these airspeeds exist and what their function and value are. It is obviously necessary to recap and once again explain CAS and IAS as they were intended, and to provide proper definitions. Therefore, these airspeeds are briefly explained and general remarks on their use are presented in § 3 below, prior to further reviewing Specification No. 1. Reference is made to the applicable aviation and other regulations for readers to be able to verify the provided recap. A pilot needs to work with CAS too, as will be explained below.

Copyright © 2026, AvioConsult. All Rights Reserved

2.4. In the fourth paragraph on page v: *"The Federal Aviation Administration has reviewed this Specification and has ". . . determined that a handbook that would meet the specification would also meet the intent of the requirements in FAR 23, which is to provide the pilot with all of the information needed to operate his aircraft in a safe manner." The Federal Aviation Administration recognized that compliance with this Specification will result in a high degree of standardization of content and format for all aircraft types and this will lead to a level of safety equal to or higher than is required under FAR 23."*

2.4.1. The first line confirms that *"the FAA has reviewed this Specification"*. After reading the review below, the reader will be able to conclude whether the FAA review was conducted with the required and expected expertise, and find an answer to the question why so many airplanes crashed after engine failure, and still do.

3. Airspeeds Explained

3.1. During reviewing AFMs, the use of Calibrated Air Speeds (CAS) and Indicated Air Speeds (IAS) was found to be neither in compliance with the way these airspeeds are defined and used in Airworthiness Standard 14 CFR FAR 23[10] and equivalent, nor as used during airplane design as taught at aeronautical universities[11], and nor as taught at Test Pilot Schools for experimental flight testing, including the calibration of pitot-static systems. POH/AFM-writers, approving authorities, and pilots seem to struggle with understanding why these airspeeds exist and what their function is. Therefore, a few general remarks are presented prior to reviewing the AFM to become aware of the real values of the used airspeeds. Misuse of the CAS and IAS in an AFM led and still leads to fatal accidents, as will become clear in this review. Reference is made to the applicable aviation and other regulations; the source of the remarks below is the *Pitot-Statics and the Standard Atmosphere* course book of the USAF Test Pilot School[12] that is approved for public release and available for download from the US Archives. Instructors of test pilot schools teach and conduct pitot-static system testing, i.e. airspeed system calibrations, at least 50 times each year to and with the students; they know what they are talking about, and share their knowledge to learn from.

3.2. The Speeds of an Airplane

3.2.1. Pilots need to know what the airspeed of their airplane is, not only for navigation purposes, but also for the piloting task. Complicating is that the airplane operates in a moving atmosphere at altitudes between ground level and the maximum operating altitude of the airplane. The temperature and air pressure in the atmosphere, also called density, change during the day and with altitude, and have effect on the performance of engines, on the aerodynamic (control) surfaces of the airplane, and on measuring the airspeed. Four airspeeds used today are briefly explained, and in addition also the Minimum Control Speed $V_{MC(A)}$, because this limiting speed, that applies after engine failure, is misunderstood by most pilots, leading to accidents.

3.2.2. **True Air Speed (TAS)** is the speed of an airplane through the air mass, which is not yet disturbed and influenced by the airplane, with respect to the ambient pressure and temperature (at the flying altitude). TAS is the airspeed to be used for the navigation task, for calculating the speed and time enroute.

$$V_t = \sqrt{\left(\frac{1}{\rho_a}\right)7P_a\left(\left(\frac{P_T - P_a}{P_a}+1\right)^{\frac{2}{7}}-1\right)}$$

Figure 1. True Airspeed (TAS, V_t) equation.

TAS is not useful for the piloting task, i.e. for control and performance, because of the influence of ambient temperature and altitude (density − ρ_a and P_a in

[10] Code of Federal Regulations, Title 14, Chapter I, FAR 23, 1−1−10 Edition was used in this review. Link to 2017 version: https://www.ecfr.gov/on/2017-01-03/title-14/chapter-I/subchapter-C/part-23/subpart-B.

[11] Stability and Control during Steady Straight Flight, Airplane Design Part VII, Dr. Jan Roskam, DAR Corporation, Kansas: https://shop.darcorp.com/index.php?route=product/category&path=60

[12] *Pitot-Statics and the Standard Atmosphere*, 4th edition (July 2020), Russell E. Erb, USAF Test Pilot School, https://apps.dtic.mil/sti/pdfs/AD1115005.pdf.

Copyright © 2026, AvioConsult. All Rights Reserved

Figure 1). The use of TAS would require computing different speeds for each combination of ambient temperature and altitude. In addition, it is quite complicated to build an accurate mechanical TAS indicator to account for the temperature and altitude effects, which was the reason to introduce the **Calibrated Air Speed** (CAS), for which the *standard atmospheric pressure and temperature at sea level* are used as a reference, rather than the ambient pressure and temperature at flight altitude. CAS makes the flying task and the use of pre-determined and flight-test acquired performance data a lot more convenient.
TAS is calculated from CAS using both the actual ambient pressure altitude and the outside air temperature, using a flight computer (E6-B) or an on-board computer.
A proper definition of True Airspeed (TAS) is:

TAS is the true airspeed of the airplane in undisturbed air with respect to the ambient pressure and temperature

As the standard atmospheric pressure and density (temperature) at sea level were used as references for the CAS, TAS is equal to CAS at sea level in a standard atmosphere.

3.2.3. **Calibrated Air Speed** (CAS, or V_C) is the airspeed (velocity) of the airplane in the undisturbed free airstream, the speed at which the airplane is plowing the air and which generates the aerodynamic lift and control power. The air pressures that are representative of the speed should be sensed by a long pitot-static boom that sticks out in front of the bow wave, which is not always practical. Therefore, the total pressure (P_T) is sensed by a pitot tube mounted on fuselage or wings in disturbed air and the ambient (static) pressure (P_a or P_S) by one or two flush ports, as shown in Figure 2. Both air pressures are fed into an Air Speed Indicator (ASI) con-

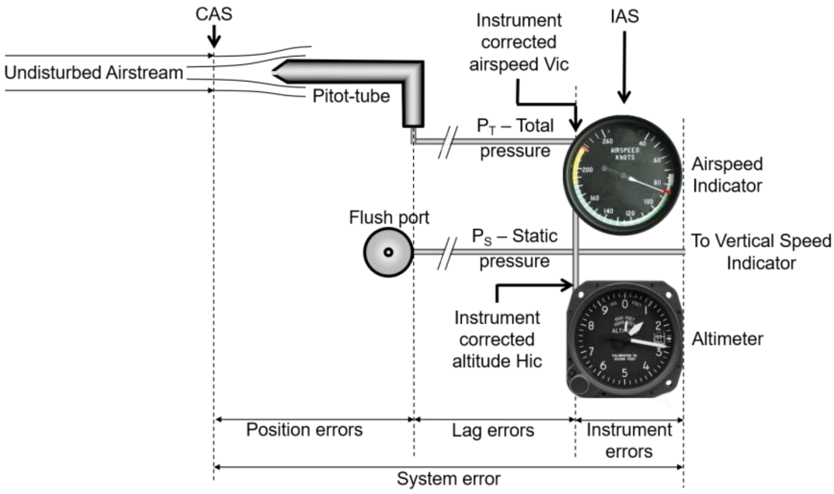


Figure 2. A common pitot-static system and its errors; from Calibrated Airspeed (CAS) in undisturbed airstream to Indicated Airspeed (IAS) on the Airspeed Indicator (ASI).

structed to sense the differential pressure $P_T - P_a$ and indicate the corresponding *calibrated airspeed with respect to the standard atmospheric pressure and density at sea level* (P_{SL} respectively ρ_{SL} in Figure 3), which are the references for CAS as already mentioned in the previous paragraph. The only variable is the differential pressure $P_T - P_a$.

$$V_c = \sqrt{\left(\frac{1}{\rho_{SL}}\right)7P_{SL}\left(\left(\frac{P_T - P_a}{P_{SL}} + 1\right)^{\frac{2}{7}} - 1\right)}$$

Figure 3. Calibrated Airspeed (CAS, V_c) equation.

At a constant differential pressure, the CAS will always be the same. Changes in sea level pressure and temperature will not affect CAS. Hence, CAS on one day is CAS on another day. Therefore, CAS is convenient for the piloting task (as compared to TAS); the AFM-published speed limitations such as V_S, V_{MC}, and V_{MO}, and operational speeds such as V_1, V_R, V_2 and V_{REF} are proportional to CAS for a given gross weight. CAS is also used to present performance data in an AFM. CAS in one airplane is CAS in another

Copyright © 2026, AvioConsult. All Rights Reserved

airplane of the same type. The CAS of two airplanes flying in formation should be equal, while their IASs are most probably not. CAS is often inappropriately explained as being the abbreviation of Computed Air Speed, even by accident investigators.

3.2.4. The definition of CAS in an AFM is almost always how to calculate CAS from IAS, like GAMA inappropriately recommends in Specification No.1: *"Calibrated Airspeed means the indicated airspeed of an airplane corrected for position and instrument error"*. *CAS is indeed IAS corrected for* instrument and position error, but *in this order*, but CAS *"means"* much more. CAS is used during flight-testing and to report limiting, operational speeds, and performance data. The use of CAS allows the manufacturer or operator to use (copies of) the same AFM for a series of airplanes of the same type that have identical pitot-static systems (position errors). The FAA or equivalent authority then must approve only one AFM. Finally, CAS is the origin of the other airspeeds and deserves an appropriate explaining definition.
Therefore, the definition of Calibrated Airspeed (CAS) should be:

CAS is the calibrated airspeed in undisturbed air with respect to the standard atmospheric pressure and temperature at sea level

3.2.5. **Indicated Airspeed**. Prior to explaining Indicated Airspeed, the pitot-static system errors (Figure 2) need some clarification. The system errors consist of position, lag, and instrument errors which will be discussed briefly.

3.2.5.1. ***Position Error***. The consequences of positioning the pressure sensors in disturbed air and flush on the fuselage are errors in the pressure measurements, called position errors. The error is influenced by the local pressures at the pitot-tube and flush port(s) due to changing angle of attack and angle of sideslip and hence, depends on airplane configuration, airspeed, weight, and altitude. FAR § 23.1323 (b) determines: *"the pitot-static system error, excluding the ASI calibration error, to not exceed the maximum of 3% of CAS or 5 kt"*. Position errors are determined during in-flight **calibration** for several configurations (flaps, gear, weight) over a range of airspeeds and altitudes and are furnished in graphs in the AFM for use by pilots.

3.2.5.2. ***Instrument Errors***. An ASI has errors too, the instrument errors, as shown in Figure 2 and requires **calibration** as well. Calibration of both the pitot-static system and the ASI gave the calibrated airspeed its name; CAS is the airspeed with maximum obtainable accuracy (for subsonic flight). The expansion of the aneroid (diaphragm or bellows) within a mechanical ASI due to the difference between P_T and P_S (= P_a) is translated by mechanical parts to the pointer of the ASI which rotates above an airspeed scale indicating the IAS. The mechanism in the ASI is designed and constructed to indicate the airspeed with respect to the standard atmospheric pressure and temperature (ISA) at sea level (equation in Figure 3).
The errors between the air pressures P_T and P_a at the entrance ports of the ASI and the eyes of the pilot(s), caused by the mechanical parts within the ASI, such as manufacturing discrepancies, magnetic fields, hysteresis or friction, altitude, temperature changes, vibration, inertia of moving parts, and the parallax, contribute to the total instrument error. The instrument error of each individual ASI over a range of airspeeds is determined in an instrument laboratory during calibration, as required by FAR § 23.1323(a) at sea level in a standard atmosphere. SAE AS 8019 presents detailed ASI specifications, but this document is not freely accessible. In another AFM, the permissible instrument error is mentioned to be ± 4 kt at speeds above 50 kt. In addition, the friction of the pointer *"must not produce an error exceeding 3 kt"*.
Hence, in a worst-case situation, the difference between the IAS indicated on two ASIs connected to the same pitot-static system is allowed to be up to 8 kt (if one error happens to be – 4 kt and the other + 4 kt) while the CASs, calculated after adding the known

Copyright © 2026, AvioConsult. All Rights Reserved

instrument correction of each ASI and the (common) position error correction of the pitot-static system, are equal.

3.2.5.3. The pressure difference P_T minus P_a (or P_S) at the entrance of the ASI is a measure of the IAS plus or minus the instrument error, and is also called the *instrument corrected airspeed* Vic (Figure 2), which is to be used as the entry variable for the position error chart in the AFM.

3.2.5.4. ***Lag errors.*** The pressure lag errors are caused by the pressure drop and the inertia of the air mass in the air tubes causing a small delay, but are considered not to have influence except when changing airspeed or altitude. These errors will not be further discussed.

3.2.5.5. ***Total system error***. The sum of both errors comprises the relationship between CAS and IAS. FAR § 23.1587(d)(10) requires this relationship to be furnished to the pilot for commuter category airplanes. The maximum regulations-approved airspeed error, being the sum of the approved instrument and position errors, is in a worst case allowed to be as high as (4 + 5 =) 9 kt (FAR § 23.1323(b) and SAE AS 8019). This number could be increased by the allowed 3 kt friction error during acceleration (takeoff) or deceleration. These are numbers that a pilot needs to be made aware of for being able to plan and conduct the takeoff, approach, and landing safely, and for handling the airplane, including in case an engine fails.

3.2.5.6. Hence, the airspeed indicated by the pointer of the ASI is not the CAS anymore; the inherent system errors (Figure 2) affect the air pressures P_T and P_a enroute from the undisturbed air ahead of the airplane to the ASI, and the conversion of the air pressures to IAS within the ASI up to the pointer. Hence, CAS cannot be directly indicated in the cockpit but must be calculated by the pilot by adding both the pitot-static position error and the ASI instrument error to the airspeed indicated by the Airspeed Indicator (ASI), and the results written on a Takeoff and Landing Data card, or by positioning bugs on the ASI. The errors can be positive, zero or negative. Backwards, when the pilot needs performance data out of the AFM while in-flight, IAS values read from the ASI need to be corrected with the instrument error (=Vic), which is then used to find the position error to be added to calculate the CAS to enter the performance graphs in the AFM.

3.2.6. **The Indicated airspeed** (IAS) is the airspeed indicated or displayed on an Airspeed Indicator (ASI), which is the CAS including the pitot-static position and airspeed instrument errors (Figure 2). An ASI is simple in design and construction and easy to calibrate, but also has unavoidable manufacturing and other instrument errors, which were already mentioned above. The errors of individual ASIs differ from each other, reason why each ASI needs to be calibrated individually in a laboratory and its error published in a calibration report (small table) and furnished to the pilot (FAR 23.1323). *The IAS indicated by two ASI's in one cockpit may disagree with ± 4 kt (total of 8 kt) due to different instrument errors.* The differences of instrument errors between ASIs in the same cockpit and in the fleet of airplanes of the same type for which a single AFM applies, and changes in instrument errors due to future maintenance replacements of ASIs, are the reasons that limiting and operational airspeeds cannot be furnished as IAS in such an AFM.

As noticed during reviews of manuals, many if not all AFM consider the instrument error to be zero, which is not in compliance with FAR 23. The large effect of a small instrument error on the control forces and moments while in-flight is described in § 3.4.4 below.
A proper definition of Indicated Airspeed (IAS) is:

IAS is the airspeed indicated on an airspeed indicator and **is CAS including the pitot-static position and instrument errors**

3.2.7. **Ground Speed (GS).** The flow of the airmass through the atmosphere, such as the wind,

also has influence on navigation. The speed of the airplane relative to the ground, called the Ground Speed, is the TAS plus or minus a tail- or headwind component. Ground speed allows calculating the distance travelled in a period.
Finally, the definition of Ground speed (GS) is:

GS is the airspeed relative to the ground, and is the TAS corrected for the wind

3.2.8. **Equivalent Airspeed** (EAS) is still taught by Test Pilot Schools and universities, and was used by pilots before World War II, but the difference with Calibrated Airspeed is small and within acceptable tolerances for Part 23 airplanes. Refer to course book *Pitot-Statics and the Standard Atmosphere* in footnote 12 on page 7 for further explanation.

3.2.9. ***Modern air data systems*** do not have a mechanical ASI anymore (except for a backup/ alternate). Pressure transducers in the air data system convert the air pressures P_T and P_S into digital data for further processing and display. Such a system however, still has the errors as shown in Figure 2. A computerized air data system should allow for entry of calibration corrections to compensate for position errors, and possibly also for (its own) pressure conversion ("instrument") errors so that CAS can be displayed on the speed tape in the cockpit, because CAS is the accurate and calibrated airspeed at which the airplane is actually plowing the air and which is also used to determine limiting and operational speeds which are published in the AFM. The piloting task becomes more convenient; the IAS indicated on the ASI then has become the CAS of the airplane, the only relevant and accurate airspeed for the piloting task which is also the only airspeed that should be used in the AFM. In most older airplanes though, the pilot must still work with both the position and instrument errors and hence with both CAS and IAS.

3.2.10. The altimeter errors were not mentioned, but are also addressed in FAR 23. The calibration is required in FAR § 23.1325(e).

3.2.11. Refer to the (free) book *Pitot-Statics and the Standard Atmosphere* in footnote 12 on page 7 for a complete course at MSc level on pitot-statics, airspeeds, altitudes, and the standard atmosphere.

3.3. Calibrated and Indicated Air Speeds in Federal Aviation Regulations (and equivalent)

3.3.1. FAR 23 "*prescribes airworthiness standards for the issue of type certificates, and changes to those certificates, for airplanes in the normal, utility, acrobatic, and commuter categories. Each person who applies under Part 21 for such a certificate or change must show compliance with the applicable requirements of this part*".
Hence, FAR 23 is intended to be used by airplane design engineers for designing airplanes (including sizing the vertical tail); and for the certification of the airworthiness of the airplanes. Non-compliance with FAR 23 renders the type certificate and hence, the certificate of airworthiness of an individual airplane invalid. Below, a few relevant FAR paragraphs are described and explained that are needed during this review.

3.3.2. GAMA Specification is originally intended for Normal Category Airplanes, but it is also used for Commuter Class AFM. Therefore, several Regulatory paragraphs of FAR 23 (1-1-10 Edition) for normal category (< 9 pax), commuter category (< 19 pax and MTOW < 19,000 lb), and SFAR No. 23 (> 10 occupants/Part 135), about airspeeds are partly copied below with some remarks added. *This chapter was originally written for an FAA certified airplane, which is the reason for references to FAR § 23. The review also applies to CS 23 paragraphs*.

3.3.3. **FAR § 23.1581(d)** requires: *"All Airplane Flight Manual operational airspeeds, unless otherwise specified, must be presented as indicated airspeeds"*. This requirement did not yet exist in the 1970 edition of FAR 23, and must have been included after the issue of GAMA Specification No. 1, which was regrettably not written with a high level of aeronautical expertise, as will be shown in this review below. It is an impossible requirement written and approved by

Copyright © 2026, AvioConsult. All Rights Reserved

incompetent people. Refer to § 3.4 below for a detailed explanation.

3.3.4. **FAA Flight Test Guide AC 23-8C**[4] in Section 2, § 3 d specifies for commuter category airplanes: *"(1) Takeoff Speeds. The following speed definitions are given in terms of calibrated airspeed".*
The "*following speed definitions*" are those of: V_{EF}, V_1, V_R, V_{LOF} and V_2. Not included are V_S and V_{MC}, although both are used to calculate V_R and V_2. Limiting speeds V_S and V_{MC} should therefore also be specified here as calibrated airspeeds, like in FAR § 23.51 and § 23.149.
These operational airspeeds are determined and/or calculated following (experimental) flight tests, and usually presented as CAS for reasons described in the paragraphs above and in § 3.4 below. These do not need to be presented in IAS in an AFM.
The AC 23-8C quote continues with: *"The AFM presentations are required, by 23.1581(d), in indicated airspeed (IAS)",* except for the *"following"* operational and limiting airspeeds, that were mentioned above. AFM presentations cannot be (accurate) in IAS in an AFM that applies to a series of airplanes, and of which the instrument errors are assumed zero. This requirement must have been included following the issue of GAMA Specification No. 1 which, as will be shown in this review, is not written with competence at a high aeronautical level of knowledge. What a pilot must do is find the appropriate and needed operational and limiting airspeeds in CAS for a particular flight in the AFM data tables and/or graphs, and correct these to IAS by applying both the position error in the AFM and the instrument error found in the calibration report of the ASI (a small table) installed in the particular airplane during prefight and present these IAS values on the Takeoff and Landing Data (TOLD) card for use in the cockpit, one for each ASI. Presenting IAS in an AFM that is for a series of airplanes is intolerable and asking for fatal accidents, and is not in compliance with FAR 23 either. See further § 3.4 below.

3.3.5. **Pt. 23, SFAR No. 23, § 5(b)(1)** requires decision speed V_1 to be in CAS. V_1 is calculated using V_S and V_{MCG}, so these speeds must also be provided in CAS (FAR § 23.51 and § 23.149).

3.3.6. **Pt. 23, SFAR No. 23, § 7** and FAR § 23.73 also require the landing approach speed V_{REF} in CAS, because the source speeds V_{MC} and V_S are in CAS (FAR § 23.51 and § 23.149).

3.3.7. **Pt. 23, SFAR No. 23, § 20 (f)** determines that the performance information in the AFM must include*: "Airspeeds, as indicated airspeeds, corresponding to those determined for takeoff in accordance with section 5(b)"*. Section 5(b) defines takeoff speeds V_1 and V_R in CAS, because V_S and V_{MC} are also determined in CAS (FAR § 23.51 and § 23.149). The instrument errors between airplanes differ, hence the takeoff speeds in IAS (as required here) will not be accurate in an AFM that applies to a series of airplanes of the same type. This is not in compliance with other paragraphs in FAR 23 either, such as § 23.51.

3.3.8. **FAR § 23.51(a)** requires rotation speed V_R for normal category airplanes to be not less than 1.05 V_{MC} or 1.1 V_{S1}. As V_{MC} and V_S are determined in CAS, V_R will also be in CAS (see also the Flight Test Guide quote in § 3.3.4 above). For commuter category airplanes (§ 23.51(c)), V_1, V_R, and V_2 must be established/selected in terms of CAS as well.
Hence, FAR § 23.51 specifies the operational takeoff speeds V_1, V_R, and V_2 and stall speed V_S to be presented as CAS in the AFM. FAR § 23.73 specifies the landing approach speed V_{REF} as CAS, and FAR § 23.149 specifies both V_{MC} and V_{MCG} as CAS. Hence, these are the operational and limiting airspeeds that are *"otherwise specified"* (§ 3.3.3 above) and hence, should not be presented as indicated airspeeds in an AFM, the reason being that these speeds are critical to flight safety and need to be quite accurate and reliable. As mentioned in § 3.3.4 above, the pilot must calculate the IAS values of the operational and limiting speeds and present these on a Takeoff and Landing Data card for use in the cockpit, and relate with the airspeed indicated on the ASI.

3.3.9. **FAR § 23.1323(a) and Pt. 23, SFAR No. 23, § 13(a)** require: "*Each airspeed indicating instrument must be calibrated to indicate true airspeed (at sea level with a standard atmosphere) with a minimum practicable instrument calibration error when the corresponding pitot and static pressures are applied*".

Copyright © 2026, AvioConsult. All Rights Reserved

Each ASI is calibrated in a laboratory to determine its instrument error, being the error between the air pressures at the entrance ports (P_T and P_a) and the airspeed indicated by the pointer on the dial of the ASI. The IAS + the instrument error is also called Vic (§ 3.2.5.3).
There is no requirement for ASI calibration at higher altitudes, only for a range of speeds at sea level, because the reference airspeed and temperature used in the ASI are standard atmospheric sea level pressure and density (Figure 3). At sea level, TAS = CAS.

3.3.10. **FAR § 23.1323 (b)** requires: "*Each airspeed system must be calibrated in flight to determine the system error. The system error, including position error, but excluding the airspeed indicator instrument calibration error, may not exceed three percent of the calibrated airspeed or five knots, whichever is greater, throughout the following speed ranges: …*"
A similar requirement in **Pt. 23, SFAR No. 23, § 13**A: "*The airspeed indicating system must be calibrated to determine the system error, i.e., the relation between IAS and CAS, in flight and during the accelerate takeoff ground run",* **and in § 13(d)**: *"information showing the relationship between IAS and CAS must be shown in the Airplane Flight Manual*".
The system error is the position error plus the lag error (Figure 2 above), but excluding the instrument error. The lag error is often neglected because it has effect only during pressure changes, which do not occur during steady straight flight.
Hence, the relationship between IAS and CAS is the sum of the instrument error of the ASI and the position error of the pitot-static system: CAS = IAS + instrument error + position error. The instrument error cannot be presented in an AFM for a series of airplanes of the same type, as explained above, only the position error must be provided in a chart or table. The instrument error should be mentioned though in the AFM, certainly in the legend of the position error chart, because the pilot must read the airspeed instrument correction from an instrument error correction table and add this to the IAS to calculate the instrument corrected airspeed (Vic) which is then used to enter the position error chart to read the position error or CAS. An IAS to Vic conversion table is to be made and be available for each individual ASI (for each serial number).

3.3.11. So, **FAR § 23.1323** requires both the pitot-static system and the airspeed indicator instrument to be calibrated separately. The calibration data of both must be made available to the pilot to be able to calculate the CAS from the IAS during flight, and to calculate pre-flight determined performance data and takeoff speeds from CAS in the AFM to IAS for use in the cockpit (on the Take Off and Landing Data (TOLD) card). The GAMA Specification No. 1 seems not to mention the instrument calibration error, on the contrary, GAMA assumes and recommends zero instrument error and therefore does not comply with FAR 23. It should not have been approved by the aviation authority.

3.3.12. **FAR 23.1581**. "*An Airplane Flight Manual must be furnished with each airplane, and it must contain the following:*
(1) Information required by §§23.1583 through 23.1589.
(2) Other information that is necessary for safe operation because of design, operating, or handling characteristics."
Not only minimum control speed V_{MC} must be furnished as number, but also its significance. V_{MC} and other information for the safe operation of the airplane after engine failure will be explained in § 3.5 below. This requirement is related to the following FAR paragraph.

3.3.13. **FAR 23.1583** requires that "*the AFM must contain operating limitations", including:*
"(1) Information necessary for the marking of the airspeed limits on the indicator as required in §23.1545, and the significance of each of those limits and of the color coding used on the indicator.
(2) The speeds V_{MC}, V_O, V_{LE}, and V_{LO}, if established, and their significance".
Hence, the marking of airspeeds limits on the indicator must be furnished in the AFM. The limiting airspeeds are established in CAS. If the instrument error is considered zero, then the markings might be on a wrong position on the indicator, or do not coincide with the AFM data. The error can be up to ± 4 kt, a range of 8 knots. In addition to the markings, the significance of the

Copyright © 2026, AvioConsult. All Rights Reserved

speeds in (2) must be contained in the AFM.

3.3.14. **In FAR § 23.1587(d):** *"In addition to paragraph (a) of this section, for commuter category airplanes, the following information must be furnished— (10): The relationship between IAS and CAS determined in accordance with §23.1323 (b) and (c)*"; (is an error, must be (a) and (b)).
The relationship between IAS and CAS is the sum of the position error (≤ 5 kt) and the instrument error (≤ 4 kt), i.e. is between 0 and 9 kt depending on the airspeed, and can be 3 kt higher due to the approved friction error when the airspeed decreases or increases.
This FAR paragraph requires both the position error and the instrument error to be furnished. The position error is usually published in a chart in the AFM, but the instrument error seems forgotten, while it can be larger than the position error. Not furnishing instrument errors, or assuming instrument errors to be zero is not in compliance with this FAR paragraph.

3.3.15. **Summary IAS and CAS in FAR**. The use of IAS and CAS in Regulations is confusing and, given the GAMA Specification No. 1, is not understood either, is even misinterpreted. The impression is that several paragraphs were changed to match GAMA Specification No.1, while other paragraphs are not. The GAMA Specification No. 1 is indeed mentioned in the FAA Flight Test Guide (page 163 and more). The consequences of changing airspeeds from CAS to IAS in POHs/AFMs might not have been obvious to the rule makers.

3.3.16. The FAR requirement for the use of IAS in AFM can only be met if, besides the position error, also the instrument errors of each individual ASI in all airplanes of the same type, for which the AFM applies, are known to the AFM-writer, including the errors of a second or third (alternate) ASI in the same cockpit. This would lead to a large data table, the use of which would be prone to errors. Requiring to present IASs in an AFM requires a separate AFM for each individual ASI (due to its instrument errors), and not just one AFM for a series of airplanes of the same type. This is expensive, and not acceptable for controlling the manuals.
A maintenance replacement of a defective ASI would lead to a change in many if not all IASs published in an AFM. Changing limiting or operational airspeeds in the FAA approved part of an AFM requires approval of the FAA and printing new manuals, which takes quite some time during which the airplane is grounded, unless the instrument error of the new ASI is the same as of the replaced ASI.
In addition to the amendment of the AFM of the specific tail number, the required red radial line indicating V_{MC} on the ASI (FAR § 23.1545(b)(6)), or for airplanes >6000 lb and turbine engine-powered airplanes the placard in the cockpit (FAR § 23.1563(c)) with airspeed limitations also needs to be amended and/or replaced. If the instrument error is considered zero, then the AFM will not include the instrument error with the consequence that the markings on the new ASI and/or placard will not be at the correct position (FAR § 23.1583). Safety is at stake.
This cannot be the intention of these FAR requirements; it is obviously unworkable, and must be in error (or is misunderstood). An ASI must be accompanied by an instrument correction table for a range of airspeeds on the instrument panel, for the pilot to be able to calculate the indicated airspeed, and the markings must be at the right place. When the author of this review started flying Part 23 airplanes in the early seventies, such a table could still be found on the instrument panel.
It seems that many manufacturers avoid the use of the instrument error by prescribing a zero-knot instrument error in their AFM, unaware of the consequences for flight safety. The relationship between CAS and IAS is then only the pitot-static position error, but this is not in compliance with FAR 23, and leads to inaccurate indication of limiting and operational speeds, and to fatal accidents.

3.3.17. **Conclusion**. FAR and SFAR 23, and FAA Flight Test Guide AC 23-8C are not very clear on the requirement for the use of CAS and/or IAS in an AFM. It appears that some paragraphs were amended following the issue of GAMA Specification No. 1, and others were not. The regulatory paragraphs are not consistent (anymore) and hence are not understood, and might have been written or amended by people who never studied pitot-static systems and airspeed properties

Copyright © 2026, AvioConsult. All Rights Reserved

and calibrations at a level higher than (airline) pilots have. FAR § 23.51, § 23.73 and § 23.149 specify the limiting and operational speeds to be established and selected as CAS. The relationship between CAS and IAS, being the sum of the position and the instrument errors, needs to be furnished to the pilot, to be able to calculate IAS from CAS and vice versa, which includes the use of the instrument error. The markings on the ASI and on the placard, must not only include the position error, but include the instrument error as well. It is neither required in FAR 23, nor possible to present accurate AFM operational airspeeds, that are determined as CAS, as indicated airspeed, if the instrument errors are unknown or are considered zero. Doing so affects flight safety.

3.4. Calibrated and Indicated Air Speeds in an AFM

3.4.1. The takeoff, stall, minimum control, cruise and landing approach speeds, and the handling qualities of the airplane were determined during experimental flight tests with a calibrated airspeed measuring system, and were reported as CAS for a given gross weight (mass). These, for flight operations important speeds are usually also published as CAS in an AFM because then they are valid for all airplanes of the same type, for which the AFM applies. As also mentioned above, another reason for publishing airspeeds as CAS is that the AFM-writer does not know the instrument error of each individual ASI installed in any production airplane (at any one time, now or in the future). The position error of the pitot-static system must be published for a range of airspeeds in a chart in the AFM. An airspeed instrument error correction table should be available showing the airspeed correction for each individual installed ASI, except for a few categories of airplanes, unless the errors are compensated for in a computerized air data system (§ 3.2.9 above). The airspeed instrument correction table should be mentioned in the AFM, like all required placards are. With this table, and with the position error chart in the AFM, the pilot can determine the Indicated Airspeed to maintain a desired Calibrated Airspeed (that is published in the AFM as limitation, procedural, or performance speed) and write these on the Take Off and Landing Data card.

3.4.2. GAMA Specification No. 1 requires airspeeds to be published as IAS, because *"the pilot exclusively works with IAS" (Preface)*. The pilot who wrote this, or who approved this on behalf of all GAMA members is not a competent pilot, and probably never studied pitot-statics at a higher level than PPL level. It is also incomprehensible that GAMA members approved this, none of them obviously consulted a graduate of one of the test pilot schools. They might not even employ one, which proves unprofessionalism, which leads to the question whether their airplanes are well developed and flight-tested.
In addition to the quote in the Preface of GAMA Specification No. 1, § 2.3 requires *"airspeed limitations and the operational significance of such limitations shall be provided as CAS and IAS (assuming zero instrument error)"*. This might cause confusion, and certainly also errors because the instrument errors of all individual airspeed indicators are and cannot be included in an AFM that applies to a series of airplanes of the same type, only the position error in the relationship between IAS and CAS can (§ 3.3.10 above).
This requirement is not in compliance with FAR 23. A recommended instrument error of zero knot might lead to controllability problems, while the pilot believes to be safe when reading the ASI, as an example will show.

3.4.3. *An example*: The minimum control speed V_{MC}, determined during experimental flight-tests, is 66 KCAS. With a position error CAS to IAS of −2 kt, and an instrument error of +4 kt, the indicated V_{MC} is 66 – 2 + 4 = 68 KIAS. In an AFM that publishes indicated airspeeds with a zero instrument error, as GAMA recommends, the published V_{MC} of 66 KCAS is indicated on the ASI as 66 – 2 = 64 KIAS. When maintaining 64 KIAS, the red-lined or placarded V_{MCA}, the pilot believes to be safe, but this airspeed is 4 kt, the magnitude of the instrument error, below the published V_{MC} (68 KIAS), and he will lose control when an engine fails, the other engine is set at maximum thrust, and the small favourable bank angle is not maintained. The takeoff speeds (in IAS), if calculated using V_{MC} as IAS with zero instrument error, will also be too low. If the V_{MC} marking on

the ASI of normal category Part 23 airplanes is positioned using both the position and the instrument errors, then the pilot will notice when his airspeed is below the published V_{MC}.
The increase of V_{MC} with the wings level is not included (§ 3.5.22). CAS and both errors are required to provide safe V_{MC} and other limiting and operational speeds to the pilot.

3.4.4. Readers, like the writers of the GAMA Specification No. 1 and the reviewers of the FAA, might believe 1, 2 or even 4 kt is not that big of an (instrument) error, so why all the fuzz. But it is not about the few knots, it's all about physics, about the forces and moments generated by the freestream air at the calibrated airspeed around the wings and the aerodynamic control surfaces that produce the Lift and the control forces which are required to maintain the equilibrium of forces and moments, i.e. to maintain control of the airplane. The aerodynamic forces are proportional to V^2, as shown in the lift equation: Lift = C_L ½ρV^2 S. A few knots difference has a large influence on the generated control forces. A rudder ratio changer in large airplanes prevents overloading the vertical fin, by reducing the rudder deflection per degree of rudder pedal travel with an inverse quadratic function of the increasing airspeed rather than with a few knots.

3.4.5. Looking at his ASI, the pilot might consider to be at the correct speed, but his controls do not produce the control forces as expected or he might not have the control travel available that he needs; control might be lost. FAR 23 requires airspeeds to be provided accurately; rules were made many years ago with competence and should not be amended or neglected by ignorance, because **physics has no mercy**.
Pilots have the right to be made aware of the errors in the pitot-static systems for them to be able to apply the correct speed corrections and hence, apply the correct and safe operational and limiting airspeeds, which were determined in CAS, to conduct a flight and return home safely. Pilots cannot be allowed to *"exclusively work with IAS"*. If they do, their airplane is not airworthy as required by FAR 23. Pilots must work with CAS in graphs and tables in a type generic AFM, and must add the position error in the AFM and the instrument error of the particular ASI in the airplane to the CAS to obtain IAS to be able to relate to, to work with, airspeed indications and markings on the ASI in that specific airplane (tail number).

3.4.6. In GAMA Specification No. 1 many more statements are found that are not in agreement with FAR 23 and FAA Flight Test Guide. The writers and/or advisors of the Specification obviously had a disappointing low-level understanding of airplane speeds, performance, and control, and of FAR 23. An AFM prepared with their Specification No. 1 did not contribute to preventing the many fatal accidents referred to in § 1.1 above. GAMA made a huge mistake by not hiring aeronautical expertise at MSc or test pilot school level. It is also incomprehensible that the FAA approved GAMA Specification No. 1 and the many different AFMs that were prepared using the Specification.

3.4.7. An AFM is designated by number in the Type Certificate Data Sheet of the airplane, and is mandatory for the airplane to be operated airworthy. Many accidents occurred and were investigated by TSBs around the globe, but obviously none of these boards reported errors in the AFM and recommended or mandated improvements during the past 50 years. Aviation is drifting into failure due to incompetence of key-personnel that the public relies on.

3.5. Minimum Control Speeds V_{MC} or V_{MCA}

3.5.1. When an engine of a multi-engine airplane fails or is inoperative, the pilot needs to counteract the asymmetrical thrust yawing and rolling forces and moments using the rudder and ailerons continuously. Therefore, a flight with asymmetrical thrust is not a coordinated flight. The forces and moments generated by the aerodynamic controls rudder and aileron are proportional to the square of the airspeed (V^2). So, whatever the attitude or configuration of the airplane, there always is an airspeed below which the asymmetrical thrust, gravity induced forces, and other forces and moments can no longer be counteracted with rudder and ailerons, and an equilibrium of forces and moments can no longer be maintained. This airspeed is called the minimum control speed.

Copyright © 2026, AvioConsult. All Rights Reserved

FAR 23 defines minimum control speed as V_{MC} for the takeoff configuration which is to be published in the AFM. Other publications also use V_{MCA}, for V_{MC} *"in the Air, or Airborne"*. Both refer to the same speed. This review uses both abbreviations separately or combined as $V_{MC(A)}$, but in addition also *"actual V_{MCA}"*, which is the V_{MC} when the configuration, flap setting, bank angle, etc. are not as prescribed in FAR 23.149 for the takeoff configuration, and a higher airspeed is required to maintain the equilibrium of forces and moments for actual circumstances, such as a larger bank angle, a non-feathered propeller, or other asymmetrical drag. A minimum control speed applies always in-flight in anticipation of, and following an engine failure, not only during takeoff. The *actual* V_{MCA} increases above the published V_{MC} with bank angle, i.e. during turns, as will be explained below.

3.5.2. During reviewing the GAMA Specification No. 1, several AFMs, and many investigation reports of accidents after engine failure, it was noticed that the pilots and the investigators were not aware of the real value of V_{MC}, and of the associated conditions for V_{MC} to be valid. Therefore below, in addition to the papers presented on the website of Avio*Consult*, a few highlights of V_{MC} are explained using FAR 23, the FAA Flight Test Guide AC 23-8C, and courses of a test pilot school, one of which is for the prediction of V_{MC} prior to conducting V_{MC} testing. Copies of the applicable Regulatory paragraphs, Flight Test Guide and course manuals are brought together in one *Background Info* pdf file[13] for the reader to verify what is written below.

3.5.3. V_{MC} is defined in FAR § 23.149(a) (and equivalent) as follows: "*V_{MC} is the calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative, and thereafter maintain straight flight at the same speed with an angle of bank of not more than 5 degrees*".

3.5.4. This definition, intended for the design and certification of airplanes, is often inappropriately copied into Airplane Flight Manuals (AFM) but is usually misunderstood by pilots and accident investigators. To improve the understanding of V_{MC}, this paragraph briefly explains the sizing of the vertical tail, the effect of bank angle on V_{MC}, and the flight test techniques used to determine V_{MC}. Readers will be become familiar with the real value of the V_{MC} that is published in the AFM of multi-engine airplanes and with the conditions for which the published V_{MC} is valid, which is of vital importance for preventing engine failure related accidents and for getting home safely after an engine failure. Accident Investigations will also improve.

3.5.5. ***Limitations Due To the Size of the Vertical Tail***. In Figure 4 below, the most important forces and moments are shown that act on a multi-engine airplane during steady straight flight when engine #1 is inoperative and the wings are kept level. As for any physical body, an airplane is in equilibrium if both the sum of the forces and the sum of the moments that act on the airplane are zero. To counteract the asymmetrical thrust yawing moment, the deflected rudder generates a side force that causes a rudder yawing moment opposite of the thrust yawing moment. The rudder side force however, also causes an acceleration to the dead engine side which results in a sideslip angle and in an opposite side force due to sideslip. The sideward acceleration continues and the resulting side force due to sideslip increases, until the sum of the side forces is zero. The aerodynamic rudder side force is proportional to the (square of the) airspeed ($\equiv V^2$). The lowest airspeed at which straight flight can just be maintained while either the rudder or the ailerons are maximum deflected and the asymmetrical thrust is maximum is called V_{MC}, in this case V_{MC} with the wings level. A sideslip however, also causes drag which reduces the remaining climb performance significantly and should therefore be kept to a minimum, especially during initial climb when an engine is inoperative, but also during cruise for maximum range. To achieve minimum sideslip hence drag, a small bank angle can be used (during straight flight), as explained next.

[13] Avio*Consult*, *Background information for the definition, theory, flight test and use of V_{MC}*, https://www.avioconsult.com/downloads/Background VMC(A) Regulations and Flight Test.pdf

Copyright © 2026, AvioConsult. All Rights Reserved

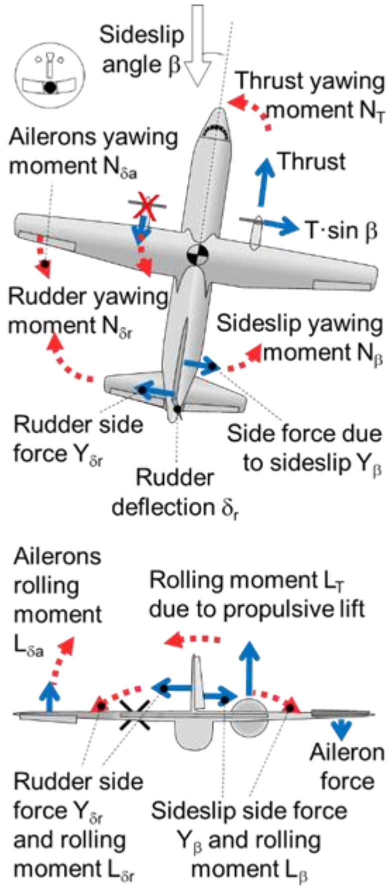


Figure 4. Lateral-Directional forces and moments in body axis coordinate system, OEI, wings level, straight flight.
Forces are not to scale.

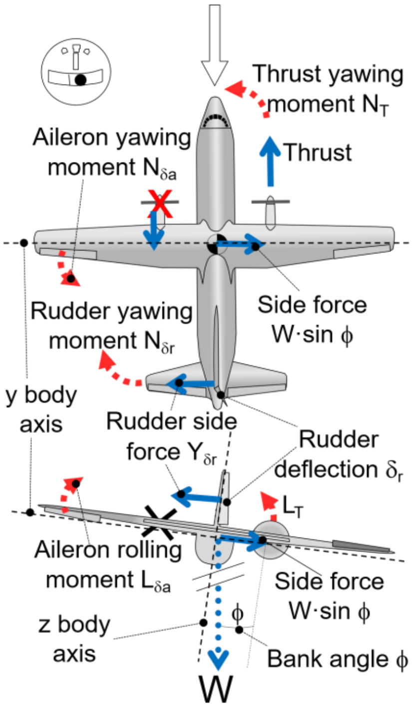


Figure 5. Lateral-Directional forces and moments in body axis coordinate system, OEI, bank angle 5° into good engine, steady straight flight.

For explaining turns, pilots use the centripetal force, being a horizontal component of the lift of the wings in the earth axis coordinate system. However, following an engine failure, the required counteracting rudder side force affects the magnitude of the centripetal force. In addition, the increased drag due to sideslip might affect the remaining wing lift. Hence, the centripetal force can only be used for coordinated flight, when all engines are operating and the controls are near center. This cannot be the case after engine failure, therefore airplane design engineers and test pilots use the *body axis coordinate system* in which a component of the weight, rather than the wing lift, provides the side force, because gravity (Weight) always acts on an airplane, whatever the bank angle or attitude. The lift of the wings acts in the direction of the z-body axis and hence, has no side component in the body-axis system, but the Weight does.

When banking, a component of the weight (W) results in a side force due to bank angle (W·sin ϕ in Figure 5), that replaces the side force due to sideslip that was a consequence of the rudder deflection (Figure 4). The small bank angle decreases the sideslip angle of the airplane to a minimum, decreasing the total drag and hence, increases the (climb) performance. Side force W·sin ϕ acts in the center of gravity (moment arm is zero) and therefore does not cause a yawing moment. As the rudder side force, generated by the vertical tail with rudder, no longer must act against the side force due to sideslip as well (see Figure 4), but only against the thrust yawing moment, the rudder deflection can be smaller, or the vertical tail can be designed smaller to save manufacturing cost and weight, and still comply with the Regulations. FAR 23.149 allows the engineer designing the vertical tail to use a bank angle of maximum 5° (away from the inoperative engine), while maintaining straight flight, for sizing the vertical tail with rudder. In any case, when maintaining a small bank angle into the good engine, V_{MC} is lower than with the wings level, and the sideslip angle is minimal.

Copyright © 2026, AvioConsult. All Rights Reserved

3.5.6. A smaller vertical tail requires a higher airspeed to counteract the same maximum thrust yawing moment; V_{MC} will be higher. FAR 23.149(b) however, does not allow the vertical tail to be made so small that V_{MC} for takeoff, i.e. during straight flight with max. 5° of bank, exceeds 1.2 times the stall speed (V_S). Hence, the vertical tail is made just large enough to be able to maintain straight flight at airspeed V_{MC} while the thrust of the opposite engine is at the maximum takeoff setting, the rudder is maximal deflected and a small bank angle is being maintained as opted during sizing the vertical tail, which is usually between 3° and 5° away from the inoperative engine. Refer to *Airplane Design Part VII,* Dr. Jan Roskam of Kansas University (footnote 2 on page 7).

The vertical tail with rudder is only sized large enough for maintaining straight flight at V_{MC} at maximum asymmetrical thrust and with 5° bank into the good engine

In-flight, the pilot controls the bank angle (if control is not lost) and hence, determines the magnitude of side force W·sin ϕ. Therefore, the effect of bank angle (ϕ) and weight on V_{MCA} is worth reviewing in greater detail.

3.5.7. ***Effect of Bank Angle and Weight on V_{MCA}***. When, during the design phase of the airplane, the size of the vertical tail with rudder is either known or assumed, graphs can be calculated using lateral-directional equations of motion with the stability derivatives of the airplane to show the effect of bank angle and weight on V_{MCA} while the thrust is maximum asymmetrical, refer to paper *The Effect of Bank Angle and Weight on V_{MCA}*[14]. The resulting graphs presented in Figure 6 and Figure 7 below are calculated in this paper using stability derivative data of a sample 4-engine turbojet airplane. Such calculations are usually also done to predict V_{MC} prior to conducting V_{MC} flight-testing with prototype airplanes. Data of a twin-engine airplane were not available; the shape of the graphs is approximately similar for all multi-engine airplane types, though.

3.5.8. Figure 6 shows that the sideslip angle β is near zero, i.e. the drag is minimal, when the bank angle is 3° away from the inoperative engine for this swept wing airplane. The corresponding *standardized* V_{MC} (with maximum rudder deflection) that is published in the AFM is 95 kt. The small bank angle should be and sometimes is included as an associated condition in the legend of one engine operating performance diagrams for the presented data to be valid.

3.5.9. As already mentioned above, bank angle not only has great effect on sideslip, hence on drag and performance, but bank angle (ϕ) and Weight (W) both have also great influence on the *actual* V_{MCA} of the airplane, being the V_{MCA} which the pilot will experience in-flight, through side force W·sin ϕ, as is illustrated in Figure 5. Figure 6 and Figure 7 show that the *actual* V_{MCA} of this sample airplane increases from the published 95 kt to 119 kt if the wings are only kept level. For small twins this increase will be ≈ 6 kt. In addition, keeping the wings level or banking to either side results in a large sideslip. Sideslip is a result, not a cause, and increases the drag and hence, reduces the climb performance or leaves no positive climb performance at all (in small twin engine airplanes).

3.5.10. Another important observation of Figure 6 should be that when banking more than 6° into the good engine, the rudder deflection should be reduced and reversed to maintain the balance of forces and moments, i.e. to maintain control. Sometimes, test pilots increase the bank angle to the point where the rudder deflection is zero, the third test point in Figure 6. At that point, the sideslip angle is near 14°, the angle at which the fin with rudder is very close to a stall, and hence, the drag very large. Figure 6 proves that it is a myth that banking into the good engine(s) is favourable to the safety margin above V_{MCA}. V_{MCA} increases considerable with banking to either side to values above V_{MC} for straight flight.

[14] AvioConsult - Harry Horlings, *The Effect of Bank Angle and Weight on V_{MCA},* https://www.avioconsult.com/downloads/Effect of Bank Angle and Weight on Vmca.pdf

Copyright © 2026, AvioConsult. All Rights Reserved

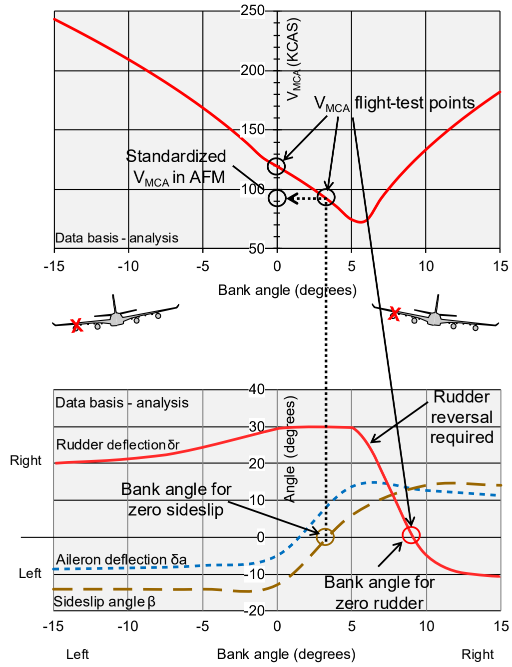


Figure 6. Effect of bank angle on V_{MCA} and on rudder, aileron, and sideslip angles during equilibrium flight at maximum thrust, for a sample airplane.

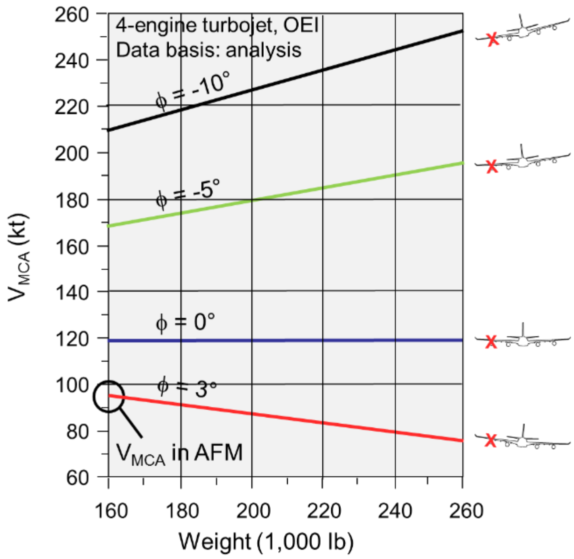


Figure 7. Effect of bank angle and weight on $V_{MC(A)}$.

NOTE. C-130 pilots know this figure, because it is like the Weight and Bank Angle figure in the C-130 Performance Manual SMP-777.

3.5.11. Figure 7 shows the effect of bank angle and weight on V_{MC}. V_{MC} when maintaining a 3° bank into the good engine decreases with increasing weight. When the wings are kept level, weight has no influence on V_{MC}; the side force due to weight ($W \cdot \sin \phi = 0$, Figure 5). This graphs also shows that V_{MC} with a small bank angle away from the failed engine is highest at low weight, which is the worst-case weight for V_{MC} during straight flight while maintaining a small bank angle, which is the reason that low weight is used to determine V_{MC}. V_{MC} increases with weight when the bank angle into the dead engine increases. At high weight (takeoff), V_{MC} increases considerable while banking. This increase is not included in Figure 6.

3.5.12. It will be clear that the requirement for maintaining straight flight while also maintaining a small bank angle away from the inoperative engine must be made well known to the pilots of multi-engine airplanes to avoid the loss of control when maximum thrust is needed on the operating engine. The saved weight and manufacturing cost of a smaller vertical tail (hardware) needs to be replaced by a quite 'heavy' associated condition / warning in the AFM (software) for only maintaining straight flight and a small bank angle while an engine is inoperative and the asymmetrical power setting is, or is increased to maximum. This prerequisite for maintaining control after engine failure is regrettably not presented anymore in most AFMs, in multi-engine rating coursebooks, and in investigator training manuals; it is forgotten knowledge during the past 50 years.

3.5.13. ***Flight-Testing To Determine V_{MCA}***. During the flight-test to determine V_{MCA} in accordance with the FAA Flight Test Guide[4], the airplane is in the same configuration as was used to design the vertical tail, of which the most important factors are the *lowest* weight possible (smallest side force $W \cdot \sin \phi$), an *aft* center of gravity (smallest rudder moment arm), maximum power setting that the pilot can set from the cockpit on the operating (critical) engine (maximum thrust yawing moment) and a feathered propeller, if applicable and automatic (lowest propeller drag). This configuration results in the 'worst-case' V_{MC} (for straight flight). Two types of V_{MC} are determined, first the static V_{MC} and then the dynamic V_{MC}.

Copyright © 2026, AvioConsult. All Rights Reserved

3.5.14. The *static V_{MC}* is the V_{MC} for maintaining straight flight while an engine is inoperative. The airspeed is slowly reduced (keeping the wings level) until the heading can no longer be maintained using maximum rudder or aileron deflection, or up to the FAR defined maximum control force limits (150 lbf for rudder pedal, 25 lbf for roll control). This first data point is the wings-level V_{MC} (Figure 4). Then, while applying the same bank angle that was used to design the vertical tail (3° to 5° away from the inoperative engine), the speed is (and can be) further reduced until again the heading can no longer be maintained. This speed is the *static* V_{MC} of the airplane and is usually between 6 (small twin) and 25 knots (B707) lower than the wings-level V_{MCA}. This V_{MC} is obviously only valid during straight flight when the small favourable bank angle is being maintained. When the bank angle for zero rudder (Figure 6) is attained, V_{MC} is a bit lower, but the sideslip (drag) increases. V_{MC} for other bank angles is never determined because of the many variables that affect the balance of forces and moments and therewith V_{MC}. The V_{MC} prediction method was used to calculate the actual airspeed for every bank angle between − 15° and + 15° for which either the rudder or the aileron deflection is maximum, or the sideslip angle is 14°, being the stall angle of attack of the fin with deflected rudder (large camber), as shown in Figure 6. The V_{MC} data on the left edge (lowest weight) of Figure 7 coincides with the V_{MC} data in Figure 6. A higher weight affects the actual V_{MC}. With zero bank angle, weight has no effect (side force W·sin 0° = 0).

3.5.15. The *dynamic V_{MC}* is important for regaining control immediately following the sudden failure of an engine during the resulting dynamics, and is determined by cutting the fuel flow to the critical engine at several speeds down to the speed at which either the heading change is maximum 20°, the bank angle does not exceed 45° and no dangerous attitudes occur.

3.5.16. The static V_{MC} is usually higher than the dynamic V_{MC}. The highest of static and dynamic V_{MC} will be published as the V_{MC} of the airplane in the AFM, but a V_{MC} applies during the whole remainder of the flight, including the final turn for landing. Flight testing (and demo) of V_{MC} is not without danger; therefore, the test data are acquired at a safe altitude and extrapolated to sea level.

3.5.17. FAR 23.149(b) defines V_{MC} for the takeoff configuration, for straight flight (climb out) at maximum thrust, and to be always as low as the red (radial) line on the ASI or as placarded. But a V_{MC} applies during the whole flight when an engine is inoperative, which might be the reason that V_{MCA} (V_{MC} in the Air) is used in many publications, including in the subject AFM. V_{MCA} is defined in POH § 0.6, while in the manual also the undefined V_{MC} is used. So, it is recommended to add the FAR 23 V_{MC} definition for the takeoff configuration and straight flight, modified for pilots, and explain in the V_{MCA} definition that an actual V_{MCA} always applies in anticipation of, and following an engine failure during the remainder of the flight, that V_{MCA} increases during turns to an undetermined actual value, and that V_{MCA} can be 'managed' with the throttle of the operating engine and with the bank angle.

3.5.18. ***Definition Of V_{MC} in an AFM.*** FAR 23 prescribes the airworthiness standards to be used by airplane design engineers (§ 3.3.1 above), including requirements for the case one of the engines is inoperative, including the provision of the minimum control speed V_{MC}. The V_{MC} definition in an AFM is often copied out of Federal Aviation Regulation (FAR 23.149) or equivalent, as quoted in § 3.5.3 above. Once the airplane is in operational use, for which the AFM applies, pilots should not keep the wings level to within 5° of bank, left or right, as the definition suggests. On the contrary, in order to ensure that control of their airplane after engine failure can be maintained when maximum thrust is set, and that the remaining climb performance is maximum achievable while one engine is inoperative, pilots need to maintain straight flight and the same small bank angle that was used to design the vertical tail and that was also used to determine the AFM-published V_{MC} during flight testing, which is usually between 3° and 5° away from the inoperative engine, as was illustrated in Figure 6 and Figure 7 above. A larger bank angle, or a bank angle into the inoperative engine, will disturb the balance of side forces and yawing moments and will result in lateral accelerations and yawing moments (and sideslip) that cannot

Copyright © 2026, AvioConsult. All Rights Reserved

guaranteed be balanced using the aerodynamic controls, simply because the vertical tail with rudder (and the ailerons) were not sized large enough to do so when the thrust is maximum. The words *suddenly made inoperative* and *critical engine* in the V_{MC} definition in an AFM do not make sense at all for, and are misleading to, pilots; a V_{MCA} applies during the entire flight, prior to and following the failure of *any* engine, not only the critical engine, and during climb, cruise and approach or go-around when any of the engines already failed during takeoff. The above quoted FAR definition of V_{MC} is deficient for use in an AFM.

3.5.19. ***The actual V_{MCA}*** that a pilot will experience in-flight will be affected by any change of lateral or directional forces and moments, for instance by an accidently deployed thrust reverser or cowling, an opened cargo hatch, a non-feathering propeller, a camera mounted on a wingtip, unbalanced wing fuel, or a bad functioning throttle friction and, last but not least, yet often occurring, intentional or uncontrolled banking at too low a speed and too high an asymmetrical thrust level (to quickly return to the runway for landing).

3.5.20. The *actual* V_{MCA} is in fact and in general the lowest airspeed which can be obtained with full directional or lateral control deflection and should be a factor of concern when the asymmetrical thrust is or is increased to maximum (during a turn).
The one engine inoperative climb performance is only maximal if a small bank angle is being maintained away from the inoperative engine; the bank angle for minimum sideslip can be less than 5° when the airspeed increases. The manufacturer should include this bank angle in the legend of the performance graphs of the AFM.

3.5.21. **In the new FAR § 23.2135 (c)** the V_{MC} definition is: "*V_{MC} is the calibrated airspeed at which, following the sudden critical loss of thrust, it is possible to maintain control of the airplane. For multiengine airplanes, the applicant must determine V_{MC}, if applicable, for the most critical configurations used in takeoff and landing operations*". After reading the explanation of V_{MC} above, readers will agree that this definition is even worse than the old one (§ 3.5.3 above). V_{MC} does not only apply during takeoff and landing operations, as accident statistics prove. V_{MC} is determined for recovery and thereafter maintaining straight flight only, while also maintaining a specific bank angle (FAA Flight Test Guide AC 23-8C[4]). The rule makers were obviously still not highly educated aeronautical engineers who understand the forces and moments acting on an airplane. It is now entirely up to the manufacturer to provide the pilots with a definition that explains V_{MC} and/or V_{MCA} so excellent and unambiguous to pilots, that accidents after engine failure will never ever occur anymore. This review proves that manufacturers are not ready to do so. Supervision with higher level knowledge is still required.

3.5.22. ***Takeoff Speeds***. The AFM-published V_{MC} is one of the factors used for calculating the takeoff speeds, including the rotation speed V_R and the takeoff safety speed V_2. Since the published V_{MC} is valid only while maintaining a small bank angle (3° to 5° away from the inoperative engine at the option of the manufacturer), both calculated takeoff speeds are also valid only while maintaining this bank angle, unless the 6 – 25 kt higher V_{MC} for wings level (depending on the type of airplane), which is also determined during flight-testing, is being used. Manufacturers regrettably never include this higher wings-level V_{MC} in their AFM, which could be the cause of many occurrences of Loss of Control just after liftoff. They don't mention the increased sideslip hence drag, i.e. the reduced or negative Rate of Climb, either.

3.5.23. The V_{MCA} data presented in Figure 6 and Figure 7 above apply for maximum asymmetrical thrust. The actual V_{MCA} decreases when reducing the asymmetrical thrust a little. This decrease can be temporarily used by pilots to conduct a turn, following a straight climb to a safe altitude. This asymmetrical thrust reduction reduces the thrust yawing moment and therewith the required counteracting rudder deflection; the actual V_{MCA} is lower. During turns, the sideslip increases though, and therewith the Rate of Climb. Some altitude might have to be sacrificed during turns, but control will be maintained. Engine-out flight is never a coordinated flight. Pilots need to be made aware and reminded of the significance of V_{MCA} for engine-out flight in the AFM, as FAR 23.1583(a)(1) requires, not only of V_{MC} for takeoff.

Copyright © 2026, AvioConsult. All Rights Reserved

3.5.24. Examples of ***controlling*** $\boldsymbol{V_{MC(A)}}$ and of **significance of** $\mathbf{V_{MC(A)}}$ are included in the following abbreviated accident reports:

> *The distribution of engine thrust for keeping the actual V_{MCA} under control, and for allowing safe turns, when one or more engines are inoperative, was applied by a competent Boeing 707 flight crew after both engines #3 and #4 separated off the right wing above the French Alps (31 March 1992). During the turns for the approach, the copilot reduced the thrust of outboard engine #1 a bit and increased the thrust of inboard engine #2, thus reducing the sum of the asymmetrical thrust yawing moments while maintaining the same total thrust level. He in fact decreased the actual V_{MCA}. He also recommended a minimum speed of 200 kt to the captain, who was the pilot-flying, and selected flaps one to unlock the outboard ailerons, therewith increasing the lateral control power. They landed safely on Airbase Istres − Le Tubé in France. Knowledge of forces and moments saved lives. Well done! Not all pilots think of managing forces and moments.*
>
> *Six months later, on 21 Dec. 1992 a Boeing 747 freighter also lost the two right engines #3 and #4 shortly after takeoff from Amsterdam Airport. Despite the damaged leading edge of the right wing, the airplane remained controllable and completed nearly two full descending turns at less than maximum thrust on engines #1 and #2. When, during a right-hand turn to position for the approach, the thrust on both left-hand engines was increased to maximum, control was lost and the airplane went down in a suburb of the city. The asymmetrical thrust yawing moment had increased above the level that could be counteracted by the aerodynamic controls. The pilots were regrettably never made aware of the effect of bank angle and thrust on the actual V_{MCA} of their airplane. The investigators of the accident interviewed the Boeing 707 pilots, but did regrettably not conclude the increase of V_{MCA} due to the inappropriate increase of thrust during the turn as cause of the accident.*

3.5.25. ***Conclusion*** of the above is that $V_{MC(A)}$ varies with bank angle and thrust level. Manufacturers are regrettably not required to publish the bank angle that was used to determine V_{MC}, neither in the V_{MC} definition, nor with V_{MC} data in the AFM, while some manufacturers do publish the bank angle for minimum drag/maximum performance in the legend of OEI performance charts (Piper in the PA-44 POH, and Lockheed in C-130 manuals). The AFM should remind pilots with: '**Published $\mathbf{V_{MC(A)}}$ is valid for straight flight only while maintaining a 5° bank angle into the good engine. $\mathbf{V_{MC(A)}}$ increases during turns**', and: **'The pilot controls the actual $\mathbf{V_{MC(A)}}$ with bank angle and (asymmetrical) level of thrust'**.

3.5.26. To prevent accidents after engine failure, the manufacturer should describe how the published $V_{MC(A)}$ is determined, when this $V_{MC(A)}$ is valid, and elaborate on the variation of $V_{MC(A)}$ with bank angle, thrust, and other effects. An improved $V_{MC(A)}$ definition for pilots could be:

'Minimum Control speed $\mathbf{V_{MC(A)}}$ is the lowest airspeed which can be obtained during steady straight flight while maintaining 5° bank towards the good engine, with full rudder and/or aileron control inputs when one engine fails or is inoperative, and the opposite engine is set at maximum thrust. **The actual $\mathbf{V_{MC(A)}}$ increases while banking to either side and with the thrust level of the good engine and hence, is controlled by the pilot'.**

3.5.27. Pilots receive their multi-engine rating in Part 23 airplanes, and take this experience with them during their whole career in Part 23 and Part 25 airplanes. Wrong learned is wrong applied. Even Boeings 747 crashed after engine(s) separation because the pilots were not made aware of the increase of $V_{MC(A)}$ to a much higher actual $V_{MC(A)}$ while banking at maximum asymmetrical thrust. ICAO would call this a Systemic Error. GAMA Specification No. 1 must therefore provide

Copyright © 2026, AvioConsult. All Rights Reserved

adequate guidance on engine-out flight to prevent future Systemic Errors as well.

3.5.28. The actual V_{MCA} depends on many factors, the worst cases of which are used during flight-testing. Actual V_{MCA} can also be lower than the AFM-published V_{MCA}, for instance due to a forward cg. The paper *Airplane Control and Analysis of Accidents after Engine Failure*[15], explains almost all about V_{MCA}, and analyses a few accidents after engine failure.
So far, the airspeed theory. In the next chapters, Specification No. 1 will be reviewed.

4. Review of Section 1. General

4.1. **§ 1.15 Propeller(s)**. Recommended is to add to the list the direction of rotation of both propellers, to be able to read which engine is the critical engine, being the engine that was made inoperative during measuring the POH/AFM-published worst-case V_{MC}. The actual $V_{MC(A)}$ when the other engine fails is usually a few knots lower, which is less critical. In case of counterrotating propellers, both engines are equally critical.

4.2. **§ 1.31 (a) General Airspeed Terminology and Symbols**. In the following paragraphs, the *"terminology and symbols"* in § 1.31 (a) are reviewed.

4.3. **CAS.** "*Calibrated Airspeed means the indicated speed of an aircraft, corrected for position and instrument error. ~~Calibrated airspeed is equal to true airspeed in standard atmosphere at sea level~~".*

4.3.1. CAS is more than 'defined' in the first sentence, which only states how to calculate CAS from IAS. But what is CAS? CAS is described in § 3.2.3 above; CAS is measured by a calibrated pitot-static system and is the airspeed at which the airplane is plowing the undisturbed air, it is the airspeed for the piloting task. Flight limitations and performance data are measured or calculated, then published in knots CAS (KCAS) in graphs, charts, and tables in the POH/AFM. CAS on one day is CAS on other days. CAS in one airplane is equal to CAS in another airplane when in line abreast formation. IASs are not, except if the position and instrument errors happen to be equal.
The definition should be: '**CAS is the airspeed in undisturbed air with respect to the standard atmospheric pressure and temperature at sea level**'. CAS is the source of other airspeeds. Compare this definition with the TAS definition below.

4.3.2. CAS cannot be indicated accurately in the cockpit due to the errors in the pitot-static system and in the airspeed indicator. FAR 23.1323 requires the calibration of both the pitot-static system and the airspeed indicator to be conducted separately to determine the position errors of the pitot-static system over a range of speeds, which are to be published in the POH/AFM, and to determine the instrument errors of the airspeed indicators, which are to be furnished to the pilot separately. The instrument error is usually not furnished in a type-generic POH/AFM, because the instrument error varies for each individual airspeed indicator. Both errors between CAS and IAS, also called 'relationship' in FAR 23 (§ 3.3.10 above), are to be used by pilots to either calculate the CAS from the IAS for looking up performance data in the POH/AFM for a given IAS, or to calculate limiting and/or performance speeds given in CAS in the POH/AFM to the IAS that is indicated in the cockpit, and should be written on the takeoff and landing data (TOLD) card.

4.3.3. The second sentence *"Calibrated airspeed is equal to true airspeed in standard atmosphere at sea level"* is true, but belongs not yet here, but in the TAS definition, and written backwards; TAS is derived from CAS and calculated using pressure altitude and ambient temperature, by the pilot using an E6-B flight computer or by on-board computers. At sea level and in standard temperature, TAS = CAS, see the last sentence of § 3.2.2 above.

4.4. **GS**. Ground Speed is the speed of an airplane relative to the ground.

[15] Harry Horlings, Avio*Consult*, *Airplane Control and Analysis of Accidents after Engine Failure*, *https://www.avioconsult.com/downloads/Airplane Control and Analysis of Accidents after Engine Failure.pdf*.

Copyright © 2026, AvioConsult. All Rights Reserved

4.4.1. In other speed definitions, the relation with another speed is mentioned. It is recommended to add: 'The Ground Speed of the airplane is equal to the TAS minus the headwind or plus the tailwind component'.

4.5. **IAS**. *"Indicated Airspeed is the speed of an aircraft as shown in the airspeed indicator ~~when corrected for instrument error~~. IAS values published in this Handbook assume zero instrument error".*

4.5.1. What is meant with *"speed"* in the first sentence? *"The speed of an aircraft as shown by the airspeed indicator when corrected for instrument error"* is the instrument corrected airspeed Vic, certainly not the IAS (§ 3.2.5.3 and Figure 1 above). Vic is to be used to enter the position error chart in the POH/AFM to read the position error for calculating CAS from IAS.

4.5.2. Assuming *"zero Instrument error"* in the definition of IAS in a POH/AFM is acting against the Regulation FAR 23, invalidating the type certificate and rendering the airplane not airworthy. Authorities should neither have approved such an advice in the GAMA Specification No. 1, nor a POH/AFM that applies zero instrument errors for ASIs in the cockpit. Refer to § 3.4.4 above for the impact of a relatively small 2 kt instrument error on the forces and moments acting on the airplane at normal flight speeds.

4.5.3. 'The IAS definition should be: '**IAS is the airspeed indicated on an airspeed indicator; IAS comprises CAS and the position and instrument errors'.** The IAS is equal to the CAS when both the pitot-static system position error and the airspeed indicator instrument error are added. These errors can be positive or negative and are unavoidable due to the manufacturing process and other reasons. The pitot static system of a type/series of airplanes is calibrated and its position error is published in the type-specific POH/AFM. In addition, each individual ASI is calibrated separately, as required by FAR 23.1323; the instrument errors of each ASI are to be furnished as well, for use by pilots. The errors can be used both ways: IAS ± instrument error ± pitot-static system position error = CAS, and vice versa. IAS in one airplane is not equal to IAS in another airplane when in line abreast formation (except if the errors happen to be equal). Limiting and operational speeds are usually furnished as CAS in a common type-specific POH/AFM, and need to be corrected by the pilot to IAS, and written on a Takeoff and Landing Data card for use with the particular ASI(s) in the cockpit.

4.5.4. IAS might differ between ASIs in the same cockpit, and will change after replacing a malfunctioning ASI. Instrument errors of ASIs are not constant, but vary with temperature, speed, and other parameters (§ 3.2.5.1 above).

4.6. **TAS.** *"True Airspeed is the airspeed of an airplane relative to undisturbed air which is the CAS corrected for altitude, temperature, and ~~compressibility~~".*

4.6.1. Compressibility is not a factor in the calculation of TAS, using CAS for a propeller airplane. A correct definition is: '**TAS is the airspeed of an airplane with respect to the ambient pressure and temperature'**. TAS is used by pilots for the navigation task. TAS is the CAS corrected for pressure altitude and outside air temperature, not for compressibility (refer to an E6-B flight computer which can be used to calculate TAS in-flight, to the book in footnote 12, page 37, and to the CAS equation in Figure 3. TAS is equal to CAS in a standard atmosphere at sea level.

4.7. **V_{MCA}.** "*Air Minimum Control Speed is the minimum flight speed at which the airplane is directionally and laterally controllable, determined in accordance with the Federal Aviation Regulations. Airplane certification conditions include one engine becoming inoperative and windmilling (or, in airplanes with autofeathering devices, feathered), not more than a 5" bank toward the operative engine, takeoff power on the operative engine, landing gear up, flaps in the takeoff position, and the most critical C.G".*

4.7.1. There are a few errors and imperfections in this definition (underlined), which might be the cause of many, if not all accidents after engine failure. V_{MCA} is explained in § 3.5 above, and an improved definitions of $V_{MC(A)}$ is presented in § 3.5.26. Remarks on the underlined words are:

4.7.2. *"Flight Speed"*. There are more flight speeds. V_{MCA} is defined in Federal Aviation Regulation FAR 23.149 as calibrated airspeed (§ 3.5.1 above).

4.7.3. *"Controllable".* FAR 23, which is for the certification of aircraft, hence for aircraft design engineers and test pilots, does not require the airplane to be *directionally and laterally controllable* at airspeed V_{MCA}, but only to be able to regain control after a sudden failure, and thereafter *maintain straight flight* when the thrust is maximum asymmetrical, and the rudder and/or ailerons are maximum deflected, or to the specified maximum control forces (§ 23.149 in § 3.5.3 above). Maintaining straight flight is not the same as "*directionally controllable*". Compare to the stall speed V_S which applies only to straight wings-level flight too; banking increases V_S, and control inputs at V_S cause a stall.
The definition of minimum control speed in general is the lowest speed at which the control surfaces generate just large enough control forces and moments to maintain the equilibrium of forces and moments to act against the forces and moments caused by asymmetrical thrust, sideslip, drag, and gravity.
For pilots it is of utmost importance to know and understand that V_{MCA} is for straight flight only when the asymmetrical thrust is maximum, and that the published V_{MCA}, just like V_S, is not valid during turns. The many accidents after engine failure, especially those shortly after liftoff, prove that an airplane is not controllable at V_{MC} or a bit higher airspeed when an engine fails or is inoperative and the other engine is set to provide maximum thrust. The increase of V_{MCA} with bank angle is much larger than the increase of V_S, though. V_{MCA} decreases when the asymmetrical thrust is decreased.

4.7.4. *"Becoming inoperative …".* V_{MCA} not only applies when an engine is becoming inoperative, but also when an engine is inoperative during the remainder of the flight. Therefore, the FAA requires both a dynamic (when becoming inoperative) and a static V_{MCA} (to maintain straight flight thereafter) to be determined[16], the highest of which (usually the static) will be published as the V_{MCA} of the airplane in the POH/AFM.

4.7.5. *"windmilling"* should be 'and its propeller windmilling'.

4.7.6. *"Not more than 5°"*. As was explained in § 3.5.8 above, a small bank angle away from the inoperative engine reduces the sideslip angle when one engine is inoperative, and increases the remaining climb performance. FAR 23 allows maximum 5°, because a larger bank angle increases the sideslip angle, and might cause the fin to stall, if the rudder is not reduced and reversed (§ 3.5.10).

4.7.7. *"flaps in the takeoff position"* in this definition means that this V_{MCA} is for takeoff as required to determine the FAR 23 defined V_{MC}; *"Flaps"* might affect the magnitude of V_{MCA}.

4.7.8. *"Most critical cg".* Meant is the effect of the length of moment arm to the cg, not only of the directional control, the rudder, but also of the lateral control, the ailerons. A shorter moment arm decreases the generated moments to counteract the thrust yawing and rolling moments, increasing V_{MC}. V_{MC} is determined with the worst-case cg, which is aft (less effective rudder) and into the inoperative engine (larger thrust yawing moment), within the approved envelope. In-flight, while an engine is inoperative, actual V_{MC} decreases when fuel is transferred to the good engine side (smaller thrust yawing moment), and weight (pax) moved forward (larger rudder yawing moment). Large required control inputs for maintaining the equilibrium of forces and moments are a signal to pilots to monitor the cg position (and the airspeed).

4.7.9. This V_{MCA} definition is not the worst definition of V_{MCA} as seen in many publications. But given the many accidents after engine failure, pilots and manual writers obviously do not understand the controllability after engine failure, and the reason why V_{MCA} needs to be determined with a 5-degree bank towards the operative engine. No word is found in the POH on the effect of

[16] FAA Flight Test Guide, Advisory Circular AC 23-8C, § 4c(6) Static V_{MCA}, and § 4c(8) Dynamic V_{MCA}. http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_23-8C.pdf.

Copyright © 2026, AvioConsult. All Rights Reserved

bank angle on V_{MCA}, i.e. when the small bank angle is not maintained, which is quite important for pilots, and will prevent accidents after engine failure. For this reason, a V_{MC}-explaining paragraph was included in § 3.5 above to emphasize the operational significance of V_{MC}. V_{MC} does not only apply in the takeoff configuration with flaps in takeoff, most critical cg or with a ≤ 5° bank angle, a V_{MC} apples during the whole flight when an engine is inoperative. Although V_{MC} is furnished in the POH/AFM, its significance and other information necessary for safe operation because of design (§ 3.5.5 above), operating, or handling characteristics (from § 3.5.7 above) are not adequately included, which is not in compliance with FAR 23.1581 and § 23.1583 (§ 3.3.12 and § 3.3.13 above). This V_{MCA} definition is deficient for pilots, and must be improved.

4.7.10. **V_{MCG}** is another minimum control speed – V_{MC} on the Ground, which applies during the takeoff run. V_{MCG} is not used in the POH, may be because the POH is not for commuter category POHs, while V_{MCG} is one of the parameters to calculate V_1 for commuter and higher-class airplanes, but also in Pt. 23, SFAR No. 23, § 5(b)(1) (§ 3.3.5). As explained above, GAMA Specification No. 1 is also used by manufacturers of airplanes certificated in the commuter and SFAR No. 23 categories, but does not mention V_{MCG}. Therefore, remarks are included.
A definition for pilots could be: 'V_{MCG} is the minimum speed at which the deviation from the takeoff path on the runway after a sudden engine failure is 30 ft or less. At takeoff run speeds lower than V_{MCG}, full rudder does not provide a large enough side force to counteract the asymmetrical thrust yawing moment. The deviation will be larger, reason why the takeoff should be aborted immediately to avoid vacating the runway.
If a runway is less than 60 ft wide, V_{MCG} should be considered higher than the published V_{MCG} and hence, V_1 will be as well. Crosswind affects the actual V_{MCG}, because some rudder is required to counteract the crosswind component and less additional rudder is available if the upwind engine fails. A V_{MCG} definition should be included in § 1.31(a).

4.8. **V_R** is required (FAR § 23.51(a), but is not included. V_R is the rotation speed, the speed at which the pilot makes a control input, with the intention of lifting the airplane out of contact with the runway or water surface. V_R for multi-engine airplanes must not be less than the greater of 1.05 V_{MC} or 1.10 V_{S1}. For single-engine landplanes, V_R must not be less than V_{S1}. A V_R definition should be included in § 1.31(a).

4.9. **V_{YSE} and V_{XSE}** are not included either, while these are used in Specification No. 1, § 3.3 (b) Airspeeds for Emergency Operations.

4.9.1. The description of both can be the same as for V_X and V_Y respectively, with the addition in both: 'when one engine is inoperative', and 'while maintaining a small bank angle into the good engine'. The manufacturer determines the magnitude of the bank angle at this higher than V_{MC} speed, which usually is 3° (for minimum sideslip and hence, maximum Rate of Climb). The bank angle should also be included in the legend of the OEI performance data charts.

4.10. **V_{REF}** is required in FAR § 23.73, and in Pt. 23, SFAR No. 23, § 7, but not included.

4.11. **§ 1.31(b) Pressure Altitude**. *"Altitude measured from standard sea level pressure (29.92 in. hg.) by a pressure or barometric altimeter. It is the indicated pressure altitude corrected for position and instrument error. In this Handbook, altimeter instrument errors are assumed to be zero"*.

4.11.1. The symbol for pressure is inHg (Inches Hydrargyrum).
Pt.23, SFAR No. 23 requires in § 14: *"The altimeter system calibration must be determined and shown in the Airplane Flight Manual".* FAR § 23.1325 (e) also requires calibration. FAR § 23.1587(a)(11) requires to furnish the altimeter system calibration in the AFM.
Assuming altimeter instrument errors to be zero is not in compliance with FAR 23, and affects the airworthiness of the airplane.

5. Review of Section 2. Limitations

5.1. **§ 2.3 Airspeed Limitations**. *"Provide airspeed limitations and the operational significance of such limitations. The name, symbol, value in knots, CAS, and IAS (assuming zero instrument error), and*

Copyright © 2026, AvioConsult. All Rights Reserved

the significance of each airspeed, shall also be provided. Where the airspeed values may be applicable to more than one configuration, the more conservative IAS value shall be used. (See Figure 2-1)".

5.1.1. This requirement does not comply with FAR 23, because *"IAS (assuming zero instrument error" "shall also be provided"*. GAMA recommends the airplane manufacturers to provide the pitot-static position errors, but not the airspeed indicator instrument error, which can be as large as the position error. The writer of this phrase obviously has objections against the use of the instrument correction, and hence tells pilots, via the recommended contents of the POH/AFM, to ignore the error, despite the requirement in FAR 23 to furnish the error (§ 4.3.2 above). When the instrument error is assumed zero, the pilot cannot explain the differences in airspeeds indicated on the two or three different airspeed indicators in the cockpit either. In a type generic POH/AFM, the IAS cannot be provided because the instrument errors are not known to the POH/AFM-writer, but must be furnished to the pilot in a different way.

5.1.2. Both the instrument and the position errors are required for the pilot to determine the Indicated Airspeed to maintain desired POH/AFM-published limiting, procedural, or performance Calibrated Airspeeds.

5.2. **Figure 2-1. Airspeed Limitations, general.** This Figure (Table) has four columns, Speed, CAS, IAS, and Remarks. The fact that an IAS column is included indicates that the writer expects that the manufacturer supplies IAS data, besides CAS data. The writer may also expect the airplane manufacturer or the pilot to fill in the IAS, but the manual is usually for a series of airplanes, not for only one tail number which has an ASI of which the instrument error might be known. Often there are more ASIs in one cockpit; then the question is for which ASI is the IAS column in Figure 2-1? And when an ASI is maintenance replaced, is the airplane then grounded until the POH/AFM is amended? Limiting airspeeds are usually in the POH/AFM part that requires approval of the FAA or equivalent organization, which takes time during which the airplane cannot be operated. To prevent this from happening, FAR 23 requires the ASI to be calibrated separately from the pitot-static system, of which the writer obviously was not aware. IAS does not belong in a POH/AFM for a series of airplanes of the same type. It will cause confusion and inaccuracies, resulting in accidents or incidents.

5.3. **V_{MCA}.** The remark in Figure 2-1 is: "*This is the minimum flight speed at which the airplane is directionally and laterally controllable, determined in accordance with the Federal Aviation Regulations*".

5.3.1. This remark is neither in accordance with the Federal Aviation Regulations (FAR 23.149), nor with the design methods used by the airplane manufacturers, and nor with the FAA Flight Test Guide either. The POH/AFM-published V_{MC} is the Calibrated Airspeed at which it is possible to recover from a sudden engine failure, and thereafter maintain straight flight and, at the option of the manufacturer, with an up to 5° of bank into the good engine.
Being controllable is quite different from the capability to maintain straight as required in FAR 23.149. Pilots often turn immediately after engine failure, or do not prevent banking, and lose control. Turning at V_{MC} with maximum asymmetrical takeoff thrust is not required in FAR 23.149; airplanes do not have to be designed to do this. When the bank angle is smaller or larger than the favorable 5° into the good engine, the actual V_{MC} increases, and if the actual airspeed is lower than the increased actual V_{MC}, then control will be lost (Figure 6 above). Many airplanes crashed due to the loss of control during turns while one or two engines were inoperative or separated from the wings, even several Boeings 747. Hence, the airplane is not controllable, the pilot cannot move around at airspeed V_{MC}, because the control surfaces are only sized to maintain the balance of forces and moments during steady straight flight. Pilots must be thoroughly made aware of this limitation (§ 3.5.6 above) to avoid casualties.

5.3.2. The interpretation of V_{MCA} in Table 2-1 is very wrong; and has caused, and will again cause fatal accidents if not improved.

Copyright © 2026, AvioConsult. All Rights Reserved

5.3.3. The significant effects of bank angle on control and performance when an engine is inoperative are not adequately explained and presented in the POH, as required by FAR § 23.1585 Operating procedures: (a) "*For all airplanes, information concerning normal, abnormal (if applicable), and emergency procedures and other pertinent information necessary for safe operation and the achievement of the scheduled performance must be furnished, including— (1) An explanation of significant or unusual flight or ground handling characteristics;*". This requirement is also included in Pt. 23, SFAR No. 23, § 20 (e).
Pilots have the right to be made aware of the bank angle for which the POH/AFM-published V_{MC} is valid, and of the large increase of V_{MC} when the bank angle and straight flight are not being maintained for *safe operation* of an engine-out airplane.

5.4. **Figure 2-2. Airspeed Indicator Markings**. This Figure also has, besides a Markings column, an *"IAS Value or Range"* column, and a column headed *"Significance"*. The *"IAS Value or Range"* column in Specification No. 1 is empty; the writer may expect here as well that the manufacturer completes this column with IAS data, which he cannot; he can only provide CAS data. Refer to § 5.2 above.

5.5. **Figure 2-2. Red Line**. The significance of the Red Line is "*Airspeed Control Speed (Multi-Engine Only)*"

5.5.1. This must be 'Minimum Control Speed (Multi-Engine Only)'. Operational significant is also that this airspeed limitation is for straight flight only while maintaining a small bank angle away from the inoperative engine. Control will be lost when banking away from the small bank angle at maximum asymmetrical thrust when the airspeed is the red-lined speed.

6. Review of Section 3. Emergency Procedures

6.1. **§ 3.1 (a) General**. *"Airspeeds used in the Emergency Procedures shall be specified in terms of Indicated Airspeed, assuming zero instrument error, in order to make the information as directly usable as possible."*

6.1.1. It would be preferrable to have safety critical airspeeds in Emergency Procedures directly readable from the ASI, but this is regrettably impossible, as explained in § 3.2 above, certainly not for older mechanical flight instruments. This line calls for neglecting the instrument error, which is not in compliance with FAR 23. The sum of both the position and the instrument errors, being the difference between CAS and IAS, is allowed to be up to (5 + 2 =) 7 knots. Hence, the Indicated airspeed is, in a worst case, allowed to be up to 7 kt higher or lower than the Calibrated Airspeed that is presented in emergency procedures in the POH/AFM. As explained above, a type generic POH/AFM can only present such data in CAS. The pilot must know about this, has the right to know for the sake of his own safety and of his passengers. Calibrated airspeeds can never be directly useable in older pitot-static systems because of the unavoidable manufacturing errors in air data systems and instruments. The intention is that a pilot, prior to takeoff and landing, finds the actual operational and limiting relevant airspeeds as CAS in the POH/AFM, adds the position and instrument errors and writes the results as IAS on a takeoff and landing data (TOLD) card to make this safety related information as directly usable as possible. Some airspeed indicators allow the setting of bugs (in IAS). Many operational and limiting speeds are weight dependent and must be looked up in graphs or tables and the position error added anyhow. It is only a small step to add the instrument error as well, but it's a giant leap towards flight safety… The writer of this line is obviously and regrettably not familiar with air data systems, airspeeds and with FAR 23 and with flying.

6.1.2. V_{MCA} is the minimum airspeed to be observed in anticipation of, and following an engine failure. When the pilot maintains V_{MCA}, without being corrected for instrument error, as displayed on the ASI and the errors, assumed to be zero, but happen to be maximal, the Calibrated Airspeed of the airplane might be lower than V_{MCA} (in CAS). When indeed an engine fails during takeoff, control will be lost at once.

Copyright © 2026, AvioConsult. All Rights Reserved

6.1.3. This line also appears in Section 3A – Abnormal Procedures, § 3A.1(a). The same remarks apply.

6.2. **§ 3.3 (b) Airspeeds for Emergency Operations**. *"In addition, for multi-engine airplanes, include the one engine inoperative best rate of climb speed (V_{YSE}), the one engine inoperative best angle of climb speed (V_{XSE}), and the air minimum control speed (V_{MCA}) with the critical engine inoperative. For these speeds, provide the significant conditions under which they may be obtained (aircraft weight, atmospheric conditions, etc.)"*.

6.2.1. V_{YSE} and V_{XSE} were not defined in § 1.31(a). Here the critical engine is mentioned, but knowing which of the engines is the critical engine is only of relevance to the test pilot who determines V_{MCA} (§ 3.5.13); the POH/AFM-published V_{MCA} is the V_{MCA} when the critical engine is inoperative, is the highest V_{MCA} after failure of either engine, the worst-case. When the other engine fails, actual V_{MCA} (§ 3.5.19) is a few knots lower, which is safer. For (airline) pilots, it should not make any difference which engine fails. The published V_{MCA} applies in anticipation of, and following the failure of either engine. The engine emergency procedures are the same after failure of either engine. So, don't mention *"critical engine"* in a procedure for pilots.

6.2.2. The significant conditions under which the mentioned speeds are obtained include not only aircraft weight and atmospheric conditions, but also the bank angle and the thrust level of the remaining engine. In fact, the magnitude of control deflections should also be mentioned, because when the rudder is not maximum deflected, as was used to determine V_{MCA}, the airspeed needs to be higher for the rudder to generate an adequate aerodynamic side force to counteract the engine yawing moment. Every pilot remembers the lift equation: Lift = $C_L \, ½ \rho V^2 S$. The aerodynamic forces generated by not only the wings, but also by the fin with rudder are proportional to the Lift Coefficient (C_L) of in this case the fin with rudder, and to the square of the airspeed (V^2), see also § 3.4.4 above.

6.2.3. It is good to include these speeds in the engine emergency procedures, but these speeds must be accompanied by *"the significant conditions under which they may be obtained"*, and hence, for which they are valid, which do not only include *"aircraft weight and atmospheric conditions"* as was shown in this review.
This objective in fact requires the manufacturer to also provide the bank angles for which V_{YSE}, V_{XSE} and V_{MCA} are valid and, in addition, to provide the significant condition that these airspeeds are valid only during *"straight flight"*, while the asymmetrical thrust is maximum, which is regrettably never done because POH/AFM writers don't know, and reviewers don't notice, while FAR 23.149 requires to determine V_{MC} for maintaining *"straight flight"* after the initial motions due to a sudden failure (§ 3.5.3). Also, a Caution should be included in Engine Emergency Procedures reminding pilots never to turn at airspeeds as low as or near V_{MCA}, but to increase airspeed first to prevent the loss of control.
Banking is much more critical than the differences between a critical and a non-critical engine. The writer of the Specification regrettably did not mention the asymmetrical thrust level, the control deflections, and the bank angle as associated significant conditions either, because he obviously didn't have the required aeronautical engineering knowledge, and was never made aware. Safety Critical Procedure Development requires high level multi-disciplinary knowledge (refer to the paper in footnote 9).

7. Review of Section 3A. Abnormal Procedures

7.1. § 3A.1 (a) General. *"Airspeeds used in this Section shall be specified in Indicated Airspeed, assuming zero instrument error, in order to make the information as directly usable as possible"*.

7.1.1. This is almost the same objective as is quoted in § 6.1 above. Refer to the remarks from § 6.1.1 above.

Copyright © 2026, AvioConsult. All Rights Reserved

8. Review of Section 4. Normal Procedures

8.1. **§ 4.1 (a General)**. *"Airspeeds used in this Section shall be specified in Indicated Airspeed, assuming zero instrument error, in order to make the information as directly usable as possible".*

8.1.1. Refer to § 6.1.1 above as well for remarks.

8.2. **§ 4.17 Procedures for Practice Demonstration of V_{MCA}**

8.2.1. During reducing the airspeed to demo V_{MCA}, several false ϕ = 0 points can be observed, when the ball is not centered; pilots need to be made aware. Demo V_{MCA} during straight flight with both bank angle zero, as well as with bank 5° into the good engine, and note the difference. Demonstration of V_{MCA} is not without risks; spin, spiral, and V_{MCA} recovery should be reviewed, and the demo conducted at a safe altitude (≥ 5000 ft AGL). Also refer to the paper in footnote 15).

8.2.2. Avio*Consult* has developed a syllabus for *V_{MCA} Training and Demonstration In-Flight*, which includes the description of the preparation, of preflight review requirements, and of the safe conduct of the demo in-flight or in a simulator.

9. Review of Section 5. Performance

9.1. **§ 5.15 Associated Conditions**. *"Each item of Airplane Performance shall include a statement of significant conditions associated with the data".* The last sentence is: *"All calibration data should cover the appropriate speed operating range. (Figure 5-2 and 5-3)".*

9.1.1. A minimum list of eight significant associated conditions is provided, but the most important associated conditions for the performance after engine failure are not, which are bank angle and speed, which should be added on top of the list, because they are most important. Refer to § 4.7 above.

9.2. **§ 5.41 Minimum Performance Presentations for ME Airplanes**.
(b) Airspeed Calibration. *"Data shall be presented as Calibrated Airspeed (CAS) versus Indicated Airspeed (IAS) assuming zero instrument error."*

9.2.1. What in fact is written here is that the difference between CAS and IAS is only the position error of the pitot-static system. The instrument error, which is allowed to be ± 2 kt (or possibly even ± 4 kt), is neglected. FAR 23 does not allow to neglect the instrument error, nor to assume a zero instrument error (§ 3.3.17). The to be presented relationship between CAS and IAS includes the instrument error. GAMA is violating FAR 23 and therewith the airworthiness requirements of airplanes.

9.2.2. These remarks also apply to Specification § 5.37 for single engine airplanes.

9.3. **§ 5.41 (d) Stall speeds.** *"Data shall be presented as indicated and calibrated airspeed versus flap configurations (any flap position for which performance has been quoted), angle of bank and weight with throttles closed*".

9.3.1. Like the other speeds, stall speeds in a POH/AFM are also determined in CAS. That is how the test pilots report V_S following flight-testing. CAS is independent of position and instrument errors. V_S cannot be presented as indicated airspeed (because the applicable instrument error is not known).

9.4. **§ 5.41 (h) Rate of Climb**.
"*3. Rate-of-Climb-one engine inoperative with flaps set to the enroute position and landing gear retracted*".

9.4.1. When one of the engines failed or is inoperative, and the wings are kept level, the airplane settles in an equilibrium of forces and moments with an unavoidable sideslip. This causes drag and reduces the climb performance. The sideslip can be reduced by attaining and maintaining a small bank angle of approximately 3° into the good engine (§ 4.9.1 above). Hence, it is

Copyright © 2026, AvioConsult. All Rights Reserved

important for the pilot to know whether the POH/AFM-presented Rate of Climb data are valid with or without the small bank angle. This should be included in the legend of the data tables or charts.

§ 5.41 (h). *"4. Rate-of-Climb-Balked Landing. The climb speeds appropriate to each configuration shall be scheduled in IAS. (Figure 5-13 or 5-14)"*

9.4.2. Once again, the climb speeds cannot be provided accurately in IAS, for reasons described above. All performance data should and can be provided in CAS only, in a type-generic POH/AFM. Most performance related airspeeds depend on the weight of the airplane; it is only a small step to add both the position and the instrument error for the performance data in IAS to be valid and accurate and write these IAS data on the Takeoff and Landing Data card.

9.5. **Figure 5-1**. **Introduction to tabulated performance.** In this Figure, IAS is presented in tabulated takeoff performance data.

9.5.1. Performance data in IAS are not accurate; CAS should be used as mentioned many times before. The airspeeds for lift-off and 50 ft height above the takeoff surface are presented in IAS. Lift-off speed is normally not used; rotation speed V_R is (FAR 23.51(a)).

9.6. **Figure 5.2. Airspeed Calibration Error – Normal System**. *"Note: Indicated Airspeed Assumes Zero Instrument Error"*.

9.6.1. Although titled Airspeed Calibration − Normal System, the chart does not present airspeed calibration, but Instrument Corrected speed (Vic) versus Calibrated Airspeed, i.e. only the position error. The note in the heading tells the pilot that the indicated airspeed assumes zero instrument error, hence, the instrument error is not included, but on the horizontal axis, the label is IAS Indicated Airspeed – knots which the pilot reads from the ASI, while the label should be IAS – Instrument Corrected speed (Vic, § 3.3.9). The pilot must add the (±) instrument error before entering the chart (Figure 2). When the instrument error is indeed zero, then Vic is equal to IAS, but most ASIs have an instrument error up to ± 4 kt (§ 3.2.5.1 above), while the position error as shown is − 3 to − 4 kt. In the legend of this chart should be included to add the instrument error to the IAS (the sum is Vic) before entering the chart to read CAS for use in performance data and for limiting speeds. The instrument error should not and may not be neglected (by FAR 23). The title of this chart should be Pitot-static system position error.
An example. If the V_{MCA} of the airplane is 84 KCAS, as measured during flight-testing, the instrument corrected IAS is 80 kt (Figure 5-2). When the instrument error is zero, the V_{MCA} shows as 80 KIAS on the airspeed indicator. However, if the instrument error was +2 kt, then the V_{MCA} of the airplane is 82 KIAS on the airspeed indicator. If the pilot maintains the red-lined V_{MCA} of 80 KIAS and an engine fails, the airspeed is 2 kt below the actual V_{MCA} (§ 3.5.19). and control will be lost, while the pilot believes to be safe. If the airspeed was decreasing, the instrument error due to lagging might be 3 kt. If the wings are kept level, the actual V_{MCA} increases too, for a DHC-6-100 with 6 kt[17]. And during other bank angles actual V_{MCA} increases even more (Figure 6 above). Airspeed theory is a bit more complicated than GAMA makes us believe it is.

9.6.2. Is *"assumed zero"* just meant for the Specification No. 1, because no airplane type/ ASI Serial Number is used? Or do manufacturers consider it an advice to assume the airspeed indicator instrument error to always be zero? Recommending to assume an error to be zero is misleading, and will have caused fatal accidents. This is not in compliance with Airworthiness Regulation FAR 23 either. The airplane may not be considered airworthy if not both the position and the instrument errors are available to the pilot and are being used. Refer to § 3.4.4 above for the large effect on airplane control of a small airspeed error.

[17] Experience of the author from V_{MCA} testing a UV-18 (DHC-6-100) during curriculum flight test training at the USAF Test Pilot School.

Copyright © 2026, AvioConsult. All Rights Reserved

9.7. **Figure 5.3**. **Airspeed Calibration Error – Normal System**.

9.7.1. The same remarks apply as for the previous Figure 5-2.

9.8. **Figure 5-4**. **Altimeter Correction − Normal System**". *Note: Indicated Airspeed and Indicated Altitude Assume Zero Instrument Error*".

9.8.1. The graph on the left side is the position error for flaps up, the graph on the right side the position error for flaps down. The errors depend not only on airspeed, but also on altitude, as shown. The airspeed on the horizontal axis for both graphs is shown to be IAS, but should be the instrument corrected IAS (Vic). Adding the instrument error to the IAS reading is required to obtain Vic.

9.8.2. As concluded above for Airspeed Calibration, these altimeter correction graphs are misleading because IAS is used, rather than instrument corrected IAS (Vic).

9.9. **Figure 5-5**. **Altimeter Correction Table**.

9.9.1. Same comments as above for Figure 5-3.

9.10. **Figure 5-6 and 5-7. Stall speeds, Power Idle**.

9.10.1. In this graph, the IAS and CAS are represented by a solid respectively dashed line that decrease with decreasing weight, as the stall speed normally does. The airspeed difference between the IAS and CAS lines is not specified in the legend as being the position error. The instrument error is not mentioned to be assumed zero, as in the legend of other graphs. The position error is usually presented in a separate graph, because it is airspeed dependent. In the Specification, the position error is presented in Figure 5-2, but the numbers are very different from the numbers in Figure 5-6. So, what do the graphs in Figure 5-6 show? Pilots have the right to be able to find correct data.

9.10.2. The remarks on Figure 5-7 are as before on tabulated CAS and IAS data. The IAS data cannot be correct for any installed ASI.

9.11. **Figure 5-13**. **Rate of Climb − One Engine Inoperative.**

9.11.1. The associated condition that a small, usually 3° of bank angle is required to achieve maximum Rate of Climb is not included in the legend of this Figure, but will be required for the presented data to be valid. The small bank angle not only decreases V_{MC} but also reduces the sideslip, and hence the drag, increasing the climb rate (Refer to Figure 6). Dr. Jan Roskam of Kansas University wrote in Airplane Design Part VII, page 286, of his college series of books for airplane design engineers, who already use V_{MC} for sizing the vertical tail: "*the V_{MC} value ultimately used ties takeoff performance to engine-out controllability*".

9.11.2. Here again, climb speed is presented in IAS, while the origin of the data is in CAS, as provided by the flight-test department of the manufacturer. IAS in one airplane is not equal to the IAS in another airplane of the same type.

9.11.3. The same remarks apply to the legends in Figures 5-14 to 5-20.

9.12. **Figure 5-30. Identification of Graphs or Tables Multi-Engine Airplanes**.

9.12.1. It must be possible for a manufacturer to calculate and present a graph with the effect of bank angle on V_{MCA}, like Figure 6 above. This will remind pilots of the requirement to increase the airspeed when turns must be made while One Engine is Inoperative. The paper referenced in footnote 14 on page 19 also presents the method to calculate a graph with V_{MCA} versus weight and bank angle when stability derivatives of the required configuration are available.

10. Review of Section 10. Safety and Operational Tips (Optional)

10.1.1. Safety tips are presented throughout this review, but, given the many accidents after engine failure, it might be worthwhile to include the following paragraphs:

10.1.2. Include a summary of airspeed measurement, calibration, and display (§ 3).

10.1.3. ***How Do I Get Home Safely After Engine Failure?*** The vertical tail of a multi-engine airplane is only made just large enough to **maintain straight flight**, while an engine is inoperative and the thrust on the operating engine(s) is maximum, down to the AFM-published $V_{MC(A)}$, provided the rudder is deflected up to maximum and **a small bank angle** between 3° and 5° (as opted by the manufacturer) is being maintained away from the inoperative engine. Only then, the manufacturer guarantees that directional control can be maintained, as required in Regulations.
This does not mean that an airplane, while an engine is inoperative, never can execute a turn safely. If one or more of the factors that have influence on $V_{MC(A)}$ are not at their worst-case value, as used during the design of the vertical tail and during $V_{MC(A)}$ flight testing, the actual $V_{MC(A)}$ is lower and a safe turn might be possible. But you may never count on this. If you need large near maximum rudder and/ or aileron deflections during straight flight, do not increase the asymmetrical thrust any further, and do not initiate a turn; the rudder and ailerons are not large enough to do so. The only safe option is to maintain straight flight while climbing to a safe altitude where the thrust (yawing moment) can be reduced a little and therewith the rudder deflection, making room for a shallow turn. During the turn, the sideslip increases, as does the drag, and some altitude will be sacrificed. Upon ending the turn, bank a few degrees away from the inoperative engine and restore the thrust again. Increasing the airspeed before turning with 20 − 30 kt also increases the safety margin above $V_{MC(A)}$.

10.1.4. If an engine fails during takeoff, input rudder as required to maintain heading (dead leg – dead engine) and continue straight ahead while banking 3° to 5° away from the inoperative engine, to the same side as the rudder. Do not turn until reaching a safe altitude and an airspeed well above V_{MCA}. Be patient, the Rate of Climb can be very small, it may take up to 30 minutes to gain some altitude. The probability that the other engine also fails is very small (unless the fuel is exhausted).

10.1.5. En-route, the airspeed will usually be high enough for maintaining control; the rudder will not have to be maximum deflected. For maximum range, a small bank angle will still be required (for minimum sideslip).

10.1.6. If the airplane does not respond adequately to control inputs, then the airspeed is below the *actual* V_{MCA} (§ 3.5.19 above), the airplane is out of control, but you are not yet lost. Just quickly reduce the asymmetrical thrust a little (to decrease the *actual* V_{MCA}) and after establishing straight flight and the small bank angle and if the airspeed is higher than V_{MCA}, restore the thrust again. If at very low altitude, the only option might be to close the throttles and land wings-level (in the dirt), which is more survivable than hitting the ground with a wing tip first.

10.1.7. ***The bottom lines***: If an engine fails or is inoperative and high asymmetrical thrust becomes necessary, bank 3° to 5° away from the inoperative engine, maintain straight flight and climb to a safe altitude where a turn can be made at less than maximum asymmetrical thrust, or a 20 − 30 kt higher speed.

10.1.8. If the airplane yaws or rolls uncommanded, reduce the asymmetrical thrust a little, attain 5° into the good engine and increase thrust again. Maintain V_{MC} or higher.

10.1.9. Plan an engine-inoperative landing well ahead, make sure you will not be needing maximum thrust during the final turn for landing. A long straight-in approach is much safer. Keep in mind that:

The AFM-published, red-lined or placarded, $V_{MC(A)}$ is not a safe minimum speed for turning!

Copyright © 2026, AvioConsult. All Rights Reserved

The manufacturer should have specified the favorable bank angles for control with the V_{MCA} definition, and for minimum drag in one engine inoperative cruise performance data in the AFM. If not found, ask for it.

11. Conclusions of the Review of GAMA Specification No. 1

11.1. Specification No. 1 of the General Aviation Manufacturers Association was, according to its Preface (§ 2.2 above), *"developed by representatives of member companies of the General Aviation Manufacturers Association (GAMA) for use in preparing Pilot's Operating Handbooks that:*

a. Are of maximum usefulness as an operating reference book for pilots;

b. Meet government regulatory requirements where applicable; and

c. Meet industry standards for scope of material, arrangement, nomenclature, and definitions".

11.2. Given the commentary in this limited review, the representatives of member companies of the GAMA who prepared Specification No. 1 were regrettably not educated at a high level of knowledge of pitot-static systems, of the function and role of airspeeds used in airplanes, and of flying qualities of multi-engine airplanes when one of the engines fails or is inoperative.
A Pilot Operating Handbook (POH) prepared using this Specification is not of maximum usefulness on these subjects as a reference book for pilots, does not meet safety-critical regulatory requirements of Federal Aviation Regulation 23, does not meet airplane design methods as taught at aeronautical universities, and does not meet experimental flight test techniques as prescribed by the FAA in Advisory Circular 23-8C, as taught at test pilot schools, and as used by their graduates in the industry either. In terms of the Cooper-Harper rating scale that test pilot schools teach to be used for the rating of handling qualities, the guidance in Specification No. 1 has major deficiencies; its improvement is mandatory.

11.3. The members of GAMA, who used Specification No. 1 to prepare the POH/AFM of their airplanes, were put on the wrong foot by a deficient Specification which obviously remained undisclosed and/or uncorrected, neither by their own engineers and test pilots during the past 50 (!) years, nor by inspectors of the FAA and equivalent authorities, nor by accident investigators of NTSB and equivalent organizations worldwide, and nor by pilots worldwide either. It is incomprehensible that obviously nobody in the 50 years that the GAMA Specification No. 1 exists reviewed it with proper knowledge, and recommended improvements. This proves incompetence at a large scale. Pilots, passengers and people at or near crash sites lost their lives because of improper manuals due to lack of knowledge. The deficient and unlawful guidance in the GAMA Specification No. 1 on the use of calibrated and indicated airspeeds and of engine failure related definitions, procedures, and safety speeds must have contributed to many if not all 520 fatal accidents and 4,150 casualties or more after engine failure during the past 25 years alone (§ 1.1). A few specific conclusions follow.

11.4. GAMA Specification No. 1 instructs the members to use Calibrated Airspeed only as necessary to comply with certification requirements, *"as the pilot works exclusively with Indicated Airspeed"*. It seems easier for a pilot to work with IAS, but this is not the intention of, and is not approved by FAR 23, because the pitot-static system always has two errors that a pilot needs to compensate for by adding corrections, the pitot-static system position error and the airspeed indicator instrument error. These errors cannot be avoided (in mechanical instruments). GAMA even recommends to assume the instrument error to be zero, and therefore does not comply with FAR 23 which requires this error to be determined and furnished to pilots. Considering the instrument error to be zero has great effect on maintaining the level of safety that airspeed limitations, furnished in the POH/AFM, are supposed to provide. A two-knot instrument error might not seem large, but such a small error at an airspeed of 80 knots has a large effect on the control power generated by the aerodynamic control surfaces and hence, on the equilibrium of forces and moments for maintaining control of the airplane (after engine failure − § 3.4.4). An indicated

Copyright © 2026, AvioConsult. All Rights Reserved

airspeed of 80 KIAS can be only 71 KCAS, the speed of the airplane through the air mass, when the errors happen to be maximum.
As the use of zero-instrument errors is not in compliance with FAR 23 airworthiness regulations; the airplane cannot be considered airworthy. Takeoff could be conducted at too low an airspeed and control could be lost when an engine fails at liftoff or shortly thereafter, the stall speed might be higher than indicated, or a tail scrape could occur during touchdown. Both the position and the instrument errors are required to be furnished to, and used by the pilots. That's the rule; the consequences of neglecting might not have been understood by GAMA.

11.5. GAMA recommends to use Indicated Airspeeds in tables and charts in a POH/AFM, but the instrument error cannot be included in the POH/AFM of a series of airplanes of the same type, because the errors of all individual Airspeed Indicators in the whole fleet, for which the POH/AFM applies, are not and cannot be known. Working with IAS in a POH/AFM would require a specific POH/AFM for every tail number, in fact for every individual Airspeed Indicator, because of the instrument errors that are different for each Airspeed Indicator. Each of these many manuals would require approval by the responsible authorities. Replacing a defective Airspeed Indicator would require a POH/AFM amendment over many pages, and approval by the authorities, which cannot be achieved, can it?
Therefore, as also required in FAR 23, all of the performance data, the airspeed limitations, and the operational speeds should be furnished in the POH/AFM as CAS, because CAS is measured by a calibrated system, applies to a whole fleet of the same airplane type, and is independent of position and instrument errors. Temperature and altitude do not affect CAS; CAS has the same significance on any day, CAS today, even if hot or high, is CAS during a standard day. CAS is the airspeed at which the airplane is plowing the air, and is therefore the most important airspeed for pilots. Before flight, pilots should look up the limiting and operational airspeeds for the actual airplane weight and other conditions, add the corresponding errors and write the resulting airspeeds as indicated airspeeds on the Takeoff and Landing Data card for easy access. When actual performance data and/or the actual true airspeed are needed in-flight, the pilot must add both errors to the actual IAS and look-up or calculate the data.
GAMA Specification No. 1 does not comply with FAR 23 and FAA Flight Test Guides on these subjects, and should not have been approved by the authorities (§ 3.3.11), neither should the POH/AFMs.

11.6. The definition and use of the minimum control speed V_{MC} or V_{MCA} is neither in compliance with its definition in FAR 23.149, nor with the way V_{MC} is determined during flight-testing in accordance with FAA Flight Test Guide AC 23-8C, nor with the airplane design techniques taught at universities. A multi-engine airplane does not have to be designed to be controllable during turns when one of the engines is inoperative, but must be designed and certificated to be able to maintain straight flight only at airspeed V_{MC}, when the asymmetrical thrust is maximum (FAR 23.149), and while maintaining a small 5° bank angle away from the failed engine. The many accidents after engine failure, especially those shortly after liftoff, prove that an airplane is not controllable at V_{MC} or a bit higher airspeed when an engine fails or is inoperative and the other engine is set to provide maximum thrust. A much higher airspeed than V_{MC} is required for maintaining control when the wings are kept level during straight flight and during turns when an engine is inoperative. A pilot controls V_{MC} with bank angle and asymmetrical thrust level (§ 3.5.24).
The significance of this operating limitation is not contained in the POH/AFM and hence, pilots are not made aware of the highly relevant associated conditions of V_{MC} either (FAR § 23.1583). GAMA Specification No. 1 does not recommend to include these as information necessary for safe operation because of design characteristics in the V_{MC} definition and in engine emergency procedures as a reminder (FAR 23.1581(a)(2)), § 3.5.25 above); the writers of Specification No. 1 were obviously not aware either, while airplane design engineers and test pilot school graduates are.

11.7. Pilots receive their multi-engine rating training in Part 23 airplanes, and take this experience with them during their whole career in Part 23 or 25 airplanes. Wrong learned is wrong applied.

Copyright © 2026, AvioConsult. All Rights Reserved

Flawed foundational knowledge on airspeed instrument error correction and on engine-out flight inevitably leads to incorrect implementation in the future, as proven by accidents after engine failure, including accidents with large airplanes (§ 3.5.24). ICAO would call the misapplication of airspeed errors and of V_{MC} *"Systemic Errors"*. Hence, GAMA Specification No. 1 is relevant to preventing Systemic Errors as well (§ 3.5.27). POH/AFMs of Part 25 airplanes should be reviewed on the same subjects, as well.

11.8. **The FAA** has reviewed and approved GAMA Specification No. 1 (as stated on page v), including the use of IAS in a POH, rather than CAS, and the use of a zero airspeed indicator instrument error. This limited review proves that a POH that meets the GAMA Specification does not meet the intent of all requirements in FAR 23, does not use the guidance for and experience of flight-testing airplanes in FAA Advisory Circular 23-8C (§ 1.3), and does not explain the flight-limitations which are the consequence of sizing the aerodynamic control surfaces by the manufacturer as small as possible, though in compliance with FAR 23.149. The definitions of the minimum control speed and other airspeeds are inappropriate, and the instrument errors of airspeed Indicators required by FAR 23 to be furnished to the pilots, are neglected. Instrument errors up to 4 kt are obviously acceptable, but can easily lead to the loss of control at low flying speeds after engine failure when not used to calculate IAS from CAS (§ 3.4.4 and § 6.2.2). By approving the use of IAS and a zero instrument error in a type specific POH, the FAA should have to approve each individual POH/AFM of a series of airplanes of the same type, because limiting and operational airspeeds require approval (§ 2.4.1).
The review of GAMA Specification No. 1 by the FAA was not adequate, the consequence being that all POH/AFMs that were prepared by GAMA members using the Specification No. 1 are deficient. Pilots of multi-engine airplanes were, and still are not adequately informed of the limitations of an engine-out airplane and of the associated conditions, as FAR 23 requires, and many of them could not prevent an accident after engine failure, and regrettably don't live to tell.

11.9. FAR, SFAR 23, and FAA Flight Test Guide AC 23-8C are not very clear on the requirement for the use of calibrated airspeeds and/or indicated airspeeds in a POH/AFM. It appears that some FAR, SFAR, and Flight Test Guide paragraphs were amended to allow IAS in the manuals following the issue of GAMA Specification No. 1, and others were not. The regulatory paragraphs are therefore not consistent (anymore) and hence are not understood. The amendments might also have been written and approved by people who never studied pitot-static systems, calibrations, and airspeed properties at a level higher than (airline or private) pilots did. FAR § 23.51, § 23.73 and § 23.149 specify the limiting and operational speeds to be established and selected as calibrated airspeed. The relationship between calibrated and indicated airspeeds, being the sum of the position and the instrument errors, needs to be furnished to the pilot, to be able to calculate indicated airspeeds from calibrated airspeeds and back. It is neither required in FAR 23, nor possible to display all POH/AFM operational and limiting airspeeds, that are determined as calibrated airspeeds, as indicated airspeed to pilots in the cockpit, except on a Takeoff and landing Data card, or by computerized air data systems. GAMA Specification No. 1 does not comply with these requirements (§ 3.3.17).

11.10. This review proves that it indeed takes high level multi-disciplinary knowledge to write faultless manuals and verify the content; it is worth the cost and effort, because it will prevent accidents and save lives, of both pilots and their passengers. Most, if not all Pilot's Operating Handbooks and Airplane Flight Manuals require review and improvement. Until this is achieved, accidents will continue to happen.
During the research for the written papers and this review, it was regrettably noticed that also very many inappropriate papers and videos on engine-out flight are published on the Internet, and on YouTube, that were made with the inspiration provided in GAMA Specification No. 1. The same is the case for questions answered by Artificial Intelligence chatbots which used the wrong sources. Artificial Intelligence on subjects described above shows Artificial Incompetence. Every pilot seems to be convinced to know all about airplanes, yet graduates of a test pilot school know there is a lot more to learn than offered on flight academies and flight schools. There

Copyright © 2026, AvioConsult. All Rights Reserved

indeed is a reason why test pilot schools were founded 80 years ago in large airplane-producing countries (§ 1.3).

11.11. Although not an objective of this limited review, it should be noted that during the 50 years that GAMA Specification No. 1 exists there obviously has been no accident investigator who ever concluded the errors in the Specification or in the POH/AFMs that were prepared using the Specification. The inappropriate guidance must have contributed to many accidents and to shortfalls in pilot training due to the use of the GAMA specified handbooks and manuals.

11.12. Poverty of knowledge leads to disinclination and incompetence, causing aviation to drift into failure, which is a process that is ongoing at an increasing pace. Philosopher Arthur Schopenhauer wrote "*Every man takes the limits of his own field of vision for the limits of the world*". For the sake of aviation safety, the self-assumed high levels of competence and experience, i.e. the own field of vision of many men and women in aviation, is not sufficiently wide to prevent fatalities; the limits of the world of aviation are much wider. Aeronautical universities and test pilot schools widen the field of vision of aviators (quite a bit); opinions of the incompetent don't, they are killing. *"You only see what you look for, and you only look for what you know"* (Goethe). Douglas Adams once said: "*Human beings, who are almost unique in having ability to learn from the experience of others, are also remarkable for their apparent disinclination to do so*". NTSB Board member Dr. Earl F. Weener used this expression in an NTSB Most Wanted List presentation "*Loss of Control During Takeoff and Landing*" (April 13, 2013). He did not mention V_{MCA}, because V_{MCA} is always considered a constant quite low speed limit, which is definitely not always the case. Investigators often conclude a stall, rather than loss of control due to the increase of actual V_{MCA}, when keeping the wings level or when banking, which they have never heard of. Dr. Weener regrettably did not respond to a letter from Avio*Consult* many years ago, nor did the FAA, ATSB, and many more organizations and manufacturers. Douglas Adams obviously hit the right note. Schopenhauer also wrote: "*The Truth Is Not Always Welcome*".
Nevertheless:
Pilots have the right to be well trained and informed about the characteristics of their airplane; passengers have the right their airplane to be operated by such pilots. Developing airplane flight and operating manuals and pilot training programs requires high level multi-disciplinary knowledge, not just a pilot license which approves operating an airplane. This is also why this review was written.

12. Recommendations

12.1. Withdraw Specification No. 1 immediately, and Inform member manufacturers of the deficiencies in Specification No. 1 as presented in this review. The Specification must be revised by people who indeed have the proper high level aeronautical expertise, who studied pitot-static systems and airplane control at MSc or test pilot school level, using this review. Airline pilots are educated and trained to operate airplanes and must participate, but most of them are not competent at a high enough level to describe and explain pitot-static systems and flying qualities of airplanes, including engine-inoperative flight. Safety Critical Procedure Development requires high level multi-disciplinary knowledge (§ 6.2.3).

12.2. To prevent any more unnecessary catastrophic accidents, GAMA should recommend member manufacturers to inform all operators of their multi-engine airplanes about unsafe definitions and associated conditions in the POH/AFM of multi-engine airplanes that were prepared using the guidance of Specification No. 1, emphasizing that only CAS data in POH/AFM should be used, that both position and instrument errors must be used to calculate the limiting and operational airspeeds in IAS rather than zero instrument errors, and that V_{MC}, takeoff speeds and single engine climb speeds are valid only during straight flight while maintaining a small 3° − 5° bank angle away from the inoperative engine, and increase considerable during turns when the asymmetrical thrust is maximum.
Pilots have the right to know and understand how to prevent a dead engine from turning into a killing engine. They have the right to read reliable airspeeds on the indicators in the cockpit.

Copyright © 2026, AvioConsult. All Rights Reserved

They have the right to be provided with excellent AFMs, POHs and training manuals. It is the duty and responsibility of the members of GAMA to furnish these (FAR 23.1585(a)(1) – § 5.3.3 above)**.**

12.3. Include in GAMA Specification No. 1, Section 10, Safety and Operational Tips, a summary of airspeed measurement, calibration, and display (§ 3.2). Also explain flight with an inoperative engine of multi-engine airplanes, including the effects of bank angle, weight, and thrust level on the minimum control speed, because there are some important unlearning and proper teaching to do (§ 3.5.25 and § 10.1.3).

12.4. Recommend manufacturers of computerized air data systems to enable entering both the position error of the pitot static system and the ("instrument") error of the air pressure converting system into the computer system following proper system calibration, and display only Calibrated Airspeeds to pilots (§ 3.2.9). Then the IAS has become the CAS. CAS is the airspeed of the airplane in undisturbed air and has the same significance on all days; CAS on one day is CAS on another day, CAS does not depend on temperature and altitude (density). CAS is the most important speed for piloting (§ 3.2.3).
In addition, present cues on the attitude display, such as advisory bank angle eyebrows, which are continuously calculated using the lateral-directional stability derivatives of the airplane for the current configuration and (asymmetrical) thrust setting, to indicate to the pilot the bank angle limits of the current airspeed and thrust setting for maintaining control of the airplane when an engine is inoperative (refer to the report in footnote 15, § 7.5.6).

12.5. Although the Specification is intended for FAR 23 normal and utility category airplanes, it is also being used for manuals for commuter class airplanes. It is recommended to include guidance for POHs of commuter class airplanes as well (§ 2.1).

12.6. Recommend the FAA, EASA and equivalent organizations to review FAR/CS 23 and equivalent, including the newer post-2015 versions, for consistent and correct use of airspeeds (§ 3.3.17) and adequate guidance for maintaining flight safety after failures. As proven in this review, the industry needs higher level guidance and supervision for preparing pilot (and training) manuals, and the approving authorities need inspectors with a higher level of knowledge.

ATTACHMENT

First 95 pages of GAMA Specification No. 1, Specification for Pilot's Operating Handbook.
(Retrieved on 2025-09-21 from: https://gama.aero/documents/gama-specification-1-specification-for-pilots-operating-handbook-version-2-0/)

GAMA Website:
https://gama.aero/facts-and-statistics/consensus-standards/publications/gama-and-industry-technical-publications-and-specifications/.

Copyright © 2026, AvioConsult. All Rights Reserved

LIST OF ABBREVIATIONS AND SYMBOLS

β	Sideslip angle	OEI	One Engine Inoperative
ρ	Air density	P_a	Ambient pressure
ϕ	Bank angle	POH	Pilot Operating Handbook
δa	Aileron deflection angle	P_S	Static pressure
δr	Rudder deflection angle	P_T	Total pressure
AC	Advisory Circular (FAA)	q_c	Dynamic pressure
AFB	Air Force Base	ROC	Rate of Climb
AFM	Airplane Flight Manual	S	Surface area
ASI	Airspeed Indicator	SE	Single Engine
ATSB	Australian Transport Safety Board	SFAR	Special Federal Aviation Regulation
CAS	Calibrated Airspeed	SL	Sea Level
CFR	Code of Federal Regulations (USA)	$T \cdot \sin \beta$	Thrust bending side force due to sideslip
cg	Center of gravity	TAS	True Airspeed
C_L	Lift coefficient	TOLD	Takeoff and Landing Data
EAS	Equivalent Airspeed	TPS	Test Pilot School
FAA	Federal Aviation Administration (USA)	USAF	United States Air Force
FAR	Federal Aviation Regulation	V	Velocity or speed
ft	foot, or feet	V_1	Decision speed
FTG	Flight Test Guide	V_2	Takeoff Safety Speed
g	Gravitational Acceleration	V_c	Calibrated Airspeed (CAS)
GAMA	General Aviation Manufacturers Association	V_{EF}	Engine Failure Speed
GS	Ground Speed	V_{ic}	Instrument Corrected Airspeed
IAS	Indicated Airspeed	V_{LOF}	Liftoff speed
ICAO	International Civil Aviation Organization	V_{MC}	Minimum Control Speed
KCAS	Knots Calibrated Airspeed	V_{MCA}	Minimum Control Speed in the Air/Airborne
KIAS	Knots Indicated Airspeed	V_{MCG}	Minimum Control Speed on the Ground
kt	knot or knots	V_R	Rotation speed
L	Lift	V_S	Stall speed
$L_{\delta a}$	Rolling moment due to aileron deflection δa	V_{S0}	Stall speed, landing configuration
$L_{\delta r}$	Rolling moment due to rudder deflection δr	V_{S1}	Stall speed, specified configuration
lbf	Pound force	V_{SR}	Reference stall speed
L_T	Rolling moment due to (asymmetric) thrust T	V_{SSE}	Safe intentional OEI speed
L_β	Rolling moment due to sideslip	V_{XSE}	Speed for best SE angle of Climb
MSc	Master of Science	V_{YSE}	Speed for best SE ROC
MTOW	Maximum Takeoff Weight	W	Weight
N	Yawing moment	$W \cdot \sin \phi$	Side force due to Weight and sinus ϕ
N_β	Yawing moment due to sideslip angle β	x	x body axis (to front and aft, thru cg)
$N_{\delta a}$	Yawing moment due to aileron deflection δa	y	y body axis (out L, R wings, thru cg)
$N_{\delta r}$	Yawing moment due to rudder deflection δr	Y_β	Side force due to sideslip angle β
N_T	Yawing moment due to (asymmetric) thrust T	$Y_{\delta r}$	Side force due to rudder deflection δr
NTSB	National Transportation Safety Board (USA)	z	z body axis (out bottom, thru cg)

Copyright © 2026, AvioConsult. All Rights Reserved

SPECIFICATION FOR PILOT'S OPERATING HANDBOOK

Retrieved 21 Sept. 2025

https://gama.aero/facts-and-statistics/consensus-standards/publications/gama-and-industry-technical-publications-and-specifications/

GAMA SPECIFICATION NO. 1

Issued: February 15,1975
Revised: October 18, 1996; Revision No. 2

Only the pages 1 -- 95 used for the review. For the remaining 72 pages download the Specification from the GAMA website.

prepared by

General Aviation Manufacturers Association

Copyright © 1996 by

General Aviation Manufacturers Association
Washington, D.C.

All rights reserved. No part of this book may be reproduced in any form without permission in writing from the publisher.

SPECIFICATION FOR PILOT'S OPERATING HANDBOOK

LOG OF REVISIONS

Rev. Date	Page No.	Description
Rev. 1 (09/01/84)	iii	Revised preface page.
	iv	Revised preface page con't.
	v	Revised title. Rev. para. 3A, 6, 7 & 10.
	0-1	Revised para. 0.1,0.3, 0.5, 0.7.
	0-2	Revised para. 0.9, 0.11, 0.13, 0.15, 0.17.
	0-3	Revised para. 0.19, 0.21, 0.23, 0.25, 0.31.
	0-4	Revised para. 0.33, 0.35, 0.41, 0.43, 0.45, 0.51.
	0-5	Revised Figure 0-1.
	0-7	Revised Figure 0-2.
	0-8	Revised Figure 0-3.
	0-9	Revised Figure 0A.
	0-10	Revised Figure 0-5.
	0-11	Revised Figure 0-6.
	1-1	Revised para. 1.1, 1.3, 1.11, 1.13.
	1-2	Revised para. 1.21, 1.23, 1.25, 1.27, 1.29, 1.31.
	1-3	Revised para. 1.31 con't.
	1-4	Revised para. 1.31 con't.
	1-5	Revised para. 1.31 con't.
	2-1	Revised para. 2.1, 2.3.
	2-2	Revised Figure 2-1.
	2-3	Revised para. 2.5.
	2-4	Revised para. 2.7, 2.9.
	2-5	Revised para. 2.11, 2.12 and Figure 2-3.
	2-6	Revised para. 2.21. 2.23, 2.37, 2.39.
	3-1	Revised para. 3.1, 3.3, 3.5, 3.7.
	3-2	Revised para. 3.9, 3.9(a), 3.9(b), 3.9(c), 3.9(d), 3.9(e), 3.9(fl, 3.9(g), 3.9(h).
	3-3	Revised para. 3.9(i).
	3A-1	Revised para. 3A. 1, 3A.3, 3A.5.
	3A-2	Revised para. 3A.7, 3A.9.
	4-1	Revised para. 4.1 ,4.3, 4.5, 4.7.
	4-2	Revised para. 4.9, 4.13, 4.15, 4.17, 4.19.
	4-3	Revised para. 4.19 con't.
	5-1	Revised para. 5.1, 5.3, 5.7, 5.9, 5.11, 5.13, 5.15.
	5-2	Revised para. 5.35.
	5-3	Revised para. 5.37(e), 5.37(i).
	5-4	Revised para. 5.41(f).
	5-5	Revised para. 5.41(1) 5.
	5-7	Revised List of Figures.
	5-36	Revised page.
	5-37	Revised page.
	6-1	Revised title. Revised para. 6.1, 6.3, 6.5, 6.7, 6.9.
	6-2	Revised para 6.9 con't.

SPECIFICATION FOR PILOT'S OPERATING HANDBOOK

LOG OF REVISIONS

Rev. Date	Page No.	Description
Rev. 1 (09/01/84) (cont)	7-1	Revised title. Revised para. 7.1.
	7-3	Revised para. 7.33.
	7-4	Revised para. 7.51.
	8-1	Revised para. 8.1, 8.3, 8.9.
	8-2	Revised para. 8.15.
	9-1	Revised para. 9.1. 9.7, 9.9.
	10-1	Revised title.

Barry D. Clements, Manager
Aircraft Certification
Division, ACE-100
Revised: September 1, 1984

Rev. Date	Page No.	Description
Rev 2 (10/18/96)	iii	Revised log page
	iv	Revised preface page
	3-2	Revised para. 3.9(a), 3.9(g)
	4-2	Revised para. 4.9, 4.15
	5-6	Added para 5.42 Performance Presentations in Icing Conditions
	7-2	Revised para. 7.25(a), 7.25(g)
	10-1	Added safety tips (5)

JAN 17 1997

Michael Gallagher, Manager
Aircraft Certification Division
Small Airplane Directorate, ACE-100
Revised: October 18, 1996

PREFACE FOR REVISION 2

This revision of GAMA Specification No. 1 incorporates NTSB suggestions for inclusion of emergency procedures for supercharger/turbocharger failure, safety tips for operating in icing conditions and use of child restraint seats and normal operating procedures for short field and soft field landings. It also establishes, per FAA, the limitations of use of the specification for showing compliance with FAR 23.1581. The limitation applies to all editions of the specification and is as follows:

GAMA SPECIFICATION NO. 1 LIMITATION

Pilots Operating Handbooks prepared in accordance with "GAMA Specification No. 1", as revised through Revision No. 2, dated October 18, 1996, are appropriate for showing compliance with CAR 3, Paragraph 3.777, and FAR 23, Paragraph 23.1581 on airplanes having a certification basis including FAR 23 through Amendment 23-44 except Commuter Category (Ref. FAR 23 Amendment 23-34, Amendment 23-39 or both).

PREFACE

This Specification was developed by representatives of member companies of the General Aviation Manufacturers Association for use in preparing Pilot's Operating Handbooks that-

a. Are of maximum usefulness as an operating reference book for pilots;
b. Meet government regulatory requirements* where applicable; and
c. Meet industry standards for scope of material, arrangement, nomenclature and definitions.

This Specification is designed to provide guidance for the preparation of Handbooks for all types of general aviation airplanes originally certificated at maximum takeoff weights of 12,500 pounds or less (or 5,700 kg). Consequently, not all of the material in the Specification is applicable to any one model and provision is made for manufacturers to omit material inappropriate to specific aircraft types or models. Thus, the Specification provides flexibility in Handbook preparation based on the complexity of the airplane while maintaining a high degree of standardization of arrangement, definitions, and performance information.

The rules of construction followed in the preparation of this Specification are the same as generally used by the FAA in the preparation of its rules (See Federal Aviation Regulation 1.3). "Shall" is used in the imperative sense (that is, when there is an obligation to act in the manner specified). The word "shall" is also used in the imperative sense when there is a choice of more than one manner of fulfilling the obligation to act. In such cases, the right to choose between alternatives belongs to the Handbook (airplane) producer. For example, see Section 5, Performance, Paragraph 5.9 Format Options. This paragraph requires a presentation of data in one of only two formats - graphical or tabular. No other format is permissible. Which to use, graphical or tabular, is a choice completely up to the Handbook (airplane) producer.

When a right or privilege is conferred upon the producer of a Handbook, the word "may" is used. When a right or privilege is abridged, the words "may not" are used. Except when a specific layout, style, format, standard, etc., is required (or when a choice must be made from a specified list) the producer of the Handbook (airplane) may use whatever layout, style, format, standard, etc., he chooses. Except when the Handbook producer is restricted in choice or otherwise limited, the choice is his.

The sequence of topics in the Handbook is intended to increase in-flight usefulness. For example, the Sections on "Limitations" and "Emergency Procedures" are placed ahead of "Normal Procedures," "Performance," "Weight and Balance" and other Sections to provide easier access to information that may be required in flight.

The units used are those which will be of most value to pilots. Calibrated Airspeed (CAS) is to be used only as necessary to comply with any applicable requirements of the certificating authority as the pilot works exclusively with Indicated Airspeed (IAS). Also KNOTS are used throughout to avoid the confusion between knots (KTS) and miles per hour (MPH) in performance charts and tables.

Derived terms, such as "Density Altitude," are not used. Charts and tables are constructed so that they may be used with data directly available, such as pressure altitude and temperature.

The Specification contains little, if any, new material or novel approaches. Basically, it is a guide to industry standardization of proven concepts to be presented in a form most useful to pilots.

The Federal Aviation Administration has reviewed this Specification and has ". . . determined that a handbook that would meet the specification would also meet the intent of the requirements in FAR 23, which is to provide the pilot with all of the information needed to operate his aircraft in a safe manner." The Federal Aviation Administration recognized that compliance with this Specification will result in a high degree of standardization of content and format for all aircraft types and this will lead to a level of safety equal to or higher than is required under FAR 23.

*Note: This Specification refers to various FAA regulations. If the Specification is being used to prepare a Handbook for acceptance by an airworthiness authority other than FAA, the appropriate regulations of that airworthiness authority may be substituted.

CONTENTS

Section

0	Technical Publication Guidance
1	General
2	Limitations
3	Emergency Procedures
3A	Abnormal Procedures (Optional)
4	Normal Procedures
5	Performance
6	Weight and Balance and Equipment List (if applicable)
7	Description of the Airplane and its Systems
8	Handling, Servicing and Maintenance
9	Supplements
10	Safety and Operational Tips (Optional) Alphabetical Index (Optional)

SECTION 0

TECHNICAL PUBLICATION GUIDANCE

TABLE OF CONTENTS

Paragraph		Page
0.1	General	0-1
0.3	Cover Title	0-1
0.5	Binder Type and Page Size	0-1
0.7	Title Page	0-1
0.9	Table of Contents	0-2
0.11	Page Identification	0-2
0.13	Copy Standards	0-2
0.15	Illustrations, Figures and Tables	0-2
0.17	Schematic Diagrams, General	0-2
0.19	Schematic Diagrams, Details	0-3
0.21	Schematic Diagrams, Legends	0-3
0.23	Schematic Diagram Symbols, Devices or Codes	0-3
0.25	Tab Dividers	0-3
0.31	Contents	0-3
0.33	Order and Numbering	0-4
0.35	Subject Headings	0-4
0.41	Identifying Revised Material	0-4
0.43	Log of Revisions	0-4
0.45	Obtaining Revisions	0-4
0.51	Supplements	0-4

INTENTIONALLY LEFT BLANK

SECTION 0
TECHNICAL PUBLICATION GUIDANCE

0.1 General

In order to achieve the objective of providing the pilot with required, useful or desirable information concerning the operation of the particular airplane, in a form reasonably uniform throughout the industry, drafters of Handbooks shall follow the Specification to the extent practical. Questions of compliance with the Specification shall be referred to the General Aviation Manufacturers Association (GAMA) and the Federal Aviation Administration (FAA) for resolution. Significant opinions concerning compliance with the Specification shall be published.

0.3 Cover Title

The cover title shall be "Pilot's Operating Handbook" or "Pilot's Operating Handbook and FAA Approved Airplane Flight Manual".

The cover title and applicable airplane designation shall be prominently displayed on the cover or spine (or both) of the Handbook. Other information may be displayed on the cover.

0.5 Binder Type and Page Size

Handbooks shall be readily revisable. They may be in loose-leaf form, with durable, multi-ring cover, or permanently bound. If in loose-leaf form "standard", or commonly used page sizes shall be used.

0.7 Title Page

The title page (See Figure 0-1) shall contain the following information:

1. The title, "Pilot's Operating Handbook and FAA Approved Airplane Flight Manual" for all airplanes except those for which the airplane manufacturer elected to provide a separate FAA Approved Airplane Flight Manual. In the latter case, the title shall be "Pilot's Operating Handbook".

Note: After the effective date of this revision, Pilot's Operating Handbooks for newly manufactured airplanes must be FAA Approved Airplane Flight Manuals.

2. The manufacturer's name.
3. The Handbook producer's (airplane manufacturer's) publication identification, if applicable.
4. The airplane serial number and registration number if appropriate (leave space for insertion of these numbers).

Note: The backside of the title page should be left blank to avoid the need for revision and potential loss of the inserted airplane serial and registration numbers.

5. The airplane model number, as shown in the FAA Type Certificate Data Sheet or Aircraft Specification and, at the Handbook producer's option, the type certification number or common airplane name, or both.
6. An applicability statement, prominently displayed, and similar to the following example (as appropriate).

"FAA approved in the normal category based on FAR 23. This document must be carried in the airplane at all times."

7. In Handbooks for airplanes required to have (or for which the airplane manufacturer has elected to Provide) FAA Approved Airplane Flight Manuals, the statement:

"THIS HANDBOOK INCLUDES THE MATERIAL REQUIRED TO BE FURNISHED TO THE PILOT BY THE FEDERAL AVIATION REGULATIONS AND ADDITIONAL INFORMATION PROVIDED BY THE MANUFACTURER AND CONSTITUTES THE FAA APPROVED AIRPLANE FLIGHT MANUAL."

8. For Handbooks that are not FAA Approved Airplane Flight Manuals, the statement:

"THIS HANDBOOK INCLUDES THE MATERIAL REQUIRED TO BE FURNISHED TO THE PILOT BY THE FEDERAL AVIATION REGULATIONS AND ADDITIONAL INFORMATION PROVIDED BY THE MANUFACTURER."

© 1996 General Aviation Manufacturers Association

9. A statement that the Handbook meets GAMA Specification No. 1, SPECIFICATION FOR PILOT'S OPERATING HANDBOOK, dated (date of the Specification to which the particular Handbook conforms).
10. The date of FAA approval and signature and title of the certificating authority.

0.9 Table of Contents

The main text of each section shall be preceded by a Table of Contents, listing the paragraph heads in numerical page order. Subparagraphs and other pertinent information, such as a list of figures, may be shown in the Table of Contents of the Section.

0.11 Page Identification

The page numbers in each section will include the section number and a dash (i.e. "3-" for all pages in the "Emergency Procedures" section) followed by the serial number of the page beginning with "I" for each section, such as 3-1, 3-2, etc.

Each page shall bear a page number and date of issue or revision at the bottom. The page number shall be in the lower right corner and the date of issue in the lower left corner, for right-hand pages. (Figure 0-2) The page number shall be in the lower left corner and the date of issue in the lower right corner, for left-hand pages. (Figure 0-3) Pages of permanently bound Handbooks need not be dated. Table of Contents pages shall be dated but need not be numbered.

Each page shall bear the date of the original issue until revised and, when revised, that of the latest revision. Instead of using the actual date of issue on each page of an original issue of a Handbook, the words "original issue" may be used. In such a case, the Title Page and the Table of Contents pages preceding each section of the Handbook shall bear the actual date of issue following the words "original issue".

On pages requiring folding, the fold shall be made in a manner that permits the page number to be visible. Except as provided below, a normal blank page within a page block, other than the back of a foldout page, shall be identified, with a phrase such as "This page left blank intentionally" or "Intentionally left blank".

Instead of printing either "This page left blank intentionally" or "Intentionally left blank" on blank pages, the Handbook producer may use dual page numbering on pages preceding or following a blank page. For example: 3-9 (3-10 blank) or (3-9 blank/3-10).

In the event a page must be added subsequent to the initial printing, the page shall carry the number of the preceding page with a letter suffix added. The added page(s) shall show the following page number (e.g. Page 1-6A/1-6B).

0.13 Copy Standards

Text may be prepared in one or two columns with or without justification. Warnings, cautions and notes may be used to highlight or emphasize important points. All pages (except wiring diagrams and foldouts) shall be printed on both sides. Each section shall be started on a right-hand page. The manufacturer's masthead, publication title, airplane model, and issue or revision date shall appear on all pages (that have text, illustrations, figures or tables) of loose-leaf Handbooks.

0.15 Illustrations, Figures, and Tables

Illustrations, figures and tables may be used. They should be located as close as practical to the related portions of the text. A list of figures may precede a substantial grouping of illustrations, figures and tables in a section of the Handbook.

For ease of reading and cross reference, illustrations, figures and tables should be presented in a vertical layout, if practical. When an illustration, figure or table is reproduced horizontally on a page, the top shall be placed toward the left edge of the sheet. (See Figure 0-3)

All illustrations, figures and tables shall be referenced in the text as figures or by title (or both). Each figure shall identified by a title or a figure number. Numbering shall be in numerical progression, prefixed by the Section Number (e.g., Figure 1-1, Figure 1-2; Figure 2-1, Figure 2-2).

Though techniques such as shading, crosshatching, screening or similar means are recommended, the use of color is permissible.

© 1996 General Aviation Manufacturers Association

0.17 Schematic Diagrams, General

Schematic diagrams may be used to indicate "flow" and to illustrate the operation of systems such as air control, electrical, fluid power, fuel and turbosystems. (See Figures 0-5 and 0-6)

The user of the schematic diagram is the pilot. The schematic diagram shall not be created for primary use by a mechanic or technician. The schematic diagram should tend to deal with an overall system rather than with subsystems, e.g., the air conditioning system rather than a compressor or blower within the air conditioning system.

The schematic diagram must be of sufficient size that legends, symbols, devices, codes, etc., are readable by persons with normal vision. Turn-page schematic diagrams shall be avoided to the extent practical.

In designing schematic diagrams, it may be necessary to compromise between detail necessary to make the diagram self-explanatory and the simplicity essential for ease of reading and understanding. Where schematic diagrams are complex by virtue of automatic features or interrelated controls in the subject system, these characteristics should be pointed out by means of explanatory text in the diagram, or in the accompanying text, or both.

On schematic diagrams with a large number of listed items, (e.g., an electrical schematic) the items shall be presented in a logical order, such as the sequence of the arrangement of the items in the airplane.

0.19 Schematic Diagrams, Details

The flow of the system shall receive primary attention. It shall be presented in patterned shading with a minimum of turns in the lines. Arrows shall be used to indicate flow direction when needed to understand the schematic diagram. The flow shall include the generator, tank, reservoir, or other appropriate starting point. The diagram shall be arranged so that the flow of the system can be traced with a minimum of effort. Crossovers should be avoided if practical. Return lines need not be shown in entirety unless needed to understand the system.

A separate shading pattern shall be used for each individual system on any one illustration, to distinguish between supply, pressure, return, etc.

Flow control devices within the system, such as check valves, fuel pumps, accumulators, and relays, should be included. Solenoid valves shall be shown with a notation indicating whether the valve is spring-loaded to the open or closed position.

0.21 Schematic Diagram, Legends

Space permitting, legends shall be spelled out within the diagram rather than abbreviated or keyed by numerals to a list of legends at the bottom or on an adjacent page. No abbreviations may be used unless they are universally meaningful. If an obscure abbreviation must be used because of space limitations, it shall be asterisked and spelled out in an unused portion of the image area. When text supports the illustration, the text shall employ the exact terms used in the illustration.

0.23 Schematic Diagram Symbols, Devices or Codes

The same symbol, device, or code shall be used throughout the Handbook to depict the same system, valve or control.

Whenever practical, each symbol should physically resemble the actual system component depicted in the schematic diagram. Abstractions should be avoided. If an abstraction must be used, it shall be selected from a recognized national standard or shall be a box with a title inside.

0.25 Tab Dividers

If the Handbook is prepared in looseleaf form, each section shall be marked with a plasticized tab divider. For ease of reference, the dividers shall be staggered. Tab dividers shall indicate section numbers or titles, or both. The section containing "Emergency Procedures" shall have a red plasticized tab divider. Separation of sections in permanently bound Handbooks is not required.

0.31 Contents

The Handbook shall contain the following sections in the order shown

Section 1	-	General
Section 2	-	Limitations
Section 3	-	Emergency Procedures
Section 3A	-	Abnormal Procedures (Optional)

© 1996 General Aviation Manufacturers Association

Section 4	-	Normal Procedures
Section 5	-	Performance
Section 6	-	Weight & Balance/ Equipment List
Section 7	-	Airplane & Systems Descriptions
Section 8	-	Airplane Handling, Service & Maintenance
Section 9	-	Supplements
Section 10	-	Safety and Operational Tips (Optional)
		Alphabetical Index (Optional)

Each section shall be complete within itself, with respect to page and numbering. There shall be a list of sections entitled "CONTENTS", in the front of the Handbook.

0.33 Order and Numbering

The order of presentation of the subject matter of the paragraphs used in this Specification shall be followed in each Handbook except when

(a) the inclusion of material called for in a paragraph is inappropriate for the type of airplane; or

(b) the specific section indicates, under "General", that the order of presentation of the paragraphs is for guidance only and need not be followed. (See, for example, Section 7.1, General.)

If a paragraph contains subparagraphs, the order of presentation of the subparagraphs is for guidance only and need not be followed. The Handbook producer should arrange the material within paragraphs in a manner he considers to be most informative to the kind of pilot expected to use the Handbook.

The numbering of paragraphs and subparagraphs within a section is not required. If numbered, they should be numbered sequentially and need not follow the numbering in this Specification so as to avoid "gaps" resulting from Specification material not appropriate to the type of airplane.

0.35 Subject Headings

Subject headings shall be the same as, or substantively equivalent to, the examples used in this Specification except when not appropriate because of the design or operational features of the type of airplane.

0.41 Identifying Revised Material

A revision to a page is defined as any change to the printed matter that was previously printed on that page.

Revisions, additions and deletions shall be identified by a vertical black line along the outside of the page (or the gutter on two column pages) opposite only that portion of the printed matter that was changed. In the case of a revision to an illustration, a black vertical line will appear in the left margin opposite the revision. The date of the revision shall be shown on each revised page. (See Figure 0-2)

0.43 Log of Revisions

Each Handbook shall have a log of Revisions or effective pages, listing all revisions or effective pages, immediately following the Title Page. (Note: Do not print on the back of the title page.) Following the last entry, there shall be a box containing the date of the revision and the signature (over the printed name and title) of the person approving the revision. (See Figure 0-4)

0.45 Obtaining Revisions

The Handbook shall contain information concerning the procedures or actions that need to be taken by the operator of the airplane to maintain the Handbook in a current status.

An appropriate warning or note shall be contained in each Handbook to inform the operator that a current Handbook is required to be in the airplane during flight and that it is the operator's responsibility to maintain the Handbook in a current status.

0.51 Supplements

Section 9 of this Specification contains the requirements for supplements.

© 1996 General Aviation Manufacturers Association

PILOT'S OPERATING HANDBOOK
AND
FAA APPROVED AIRPLANE
FLIGHT MANUAL

[redacted]

[redacted]

[redacted]

Serial No. ____(If appropriate)____

Registration No. ____(If appropriate)____

Type Certificate No. ________

THIS HANDBOOK INCLUDES THE MATERIAL REQUIRED TO BE FURNISHED TO THE PILOT BY THE FEDERAL AVIATION REGULATIONS AND ADDITIONAL INFORMATION PROVIDED BY THE MANUFACTURER, AND CONSTITUTES THE FAA APPROVED AIRPLANE FLIGHT MANUAL.

This Handbook meets GAMA Specification No. 1, *Specification for Pilot's Operating Handbook*, issued February 15, 1975 and revised September 1, 1984.

Approved by the Federal Aviation Administration

By: ________________________
(NAME) (TITLE)

Manufacturers Name ________

Date: ________________________

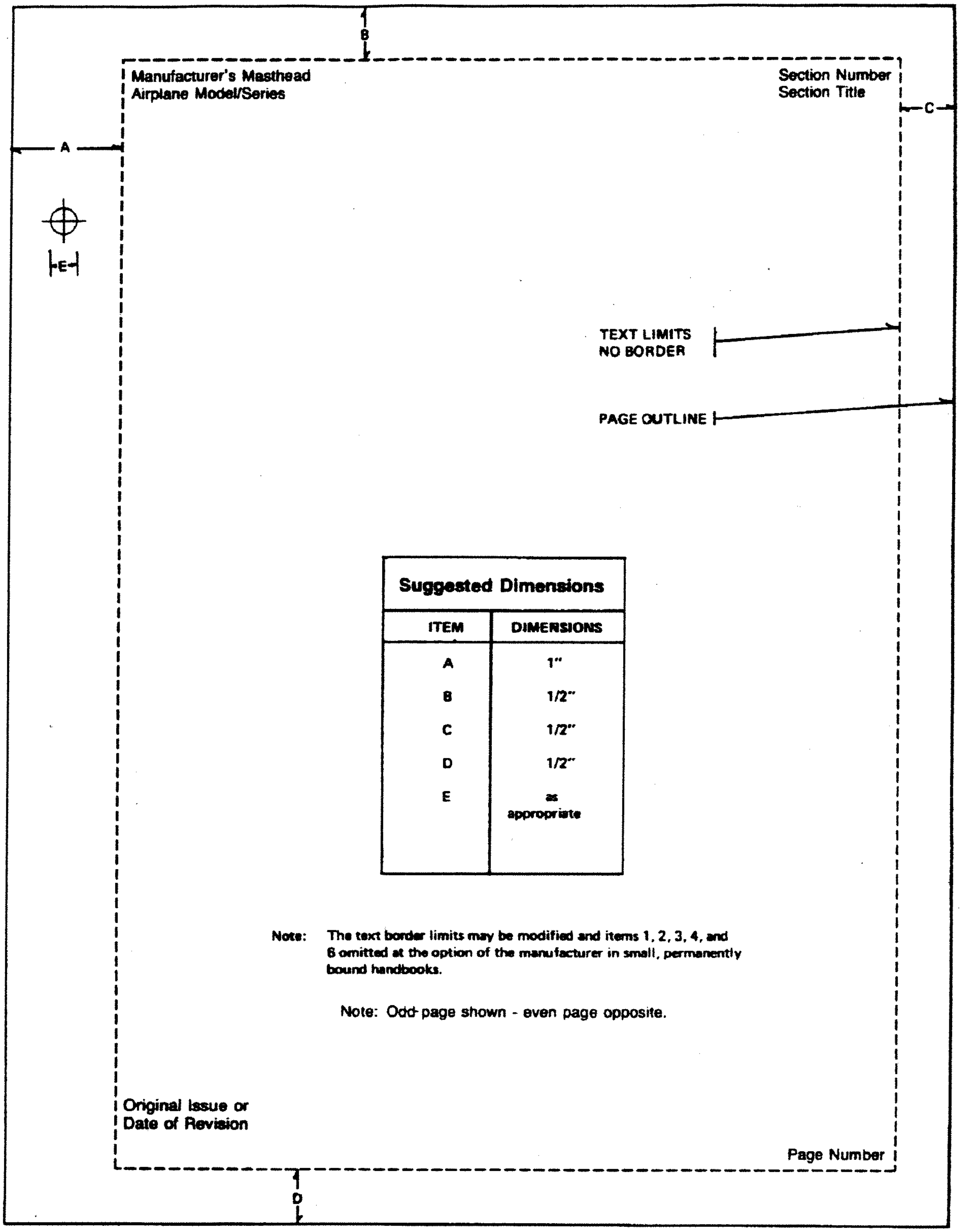
Address ________

Figure 0-1
Title Page Layout

© 1996 General Aviation Manufacturers Association

INTENTIONALLY LEFT BLANK

© 1996 General Aviation Manufacturers Association



Suggested Dimensions

ITEM	DIMENSIONS
A	1"
B	1/2"
C	1/2"
D	1/2"
E	as appropriate

Note: The text border limits may be modified and items 1, 2, 3, 4, and 6 omitted at the option of the manufacturer in small, permanently bound handbooks.

Note: Odd page shown - even page opposite.

Figure 0-2
Suggested Vertical Page Layout

© 1996 General Aviation Manufacturers Association

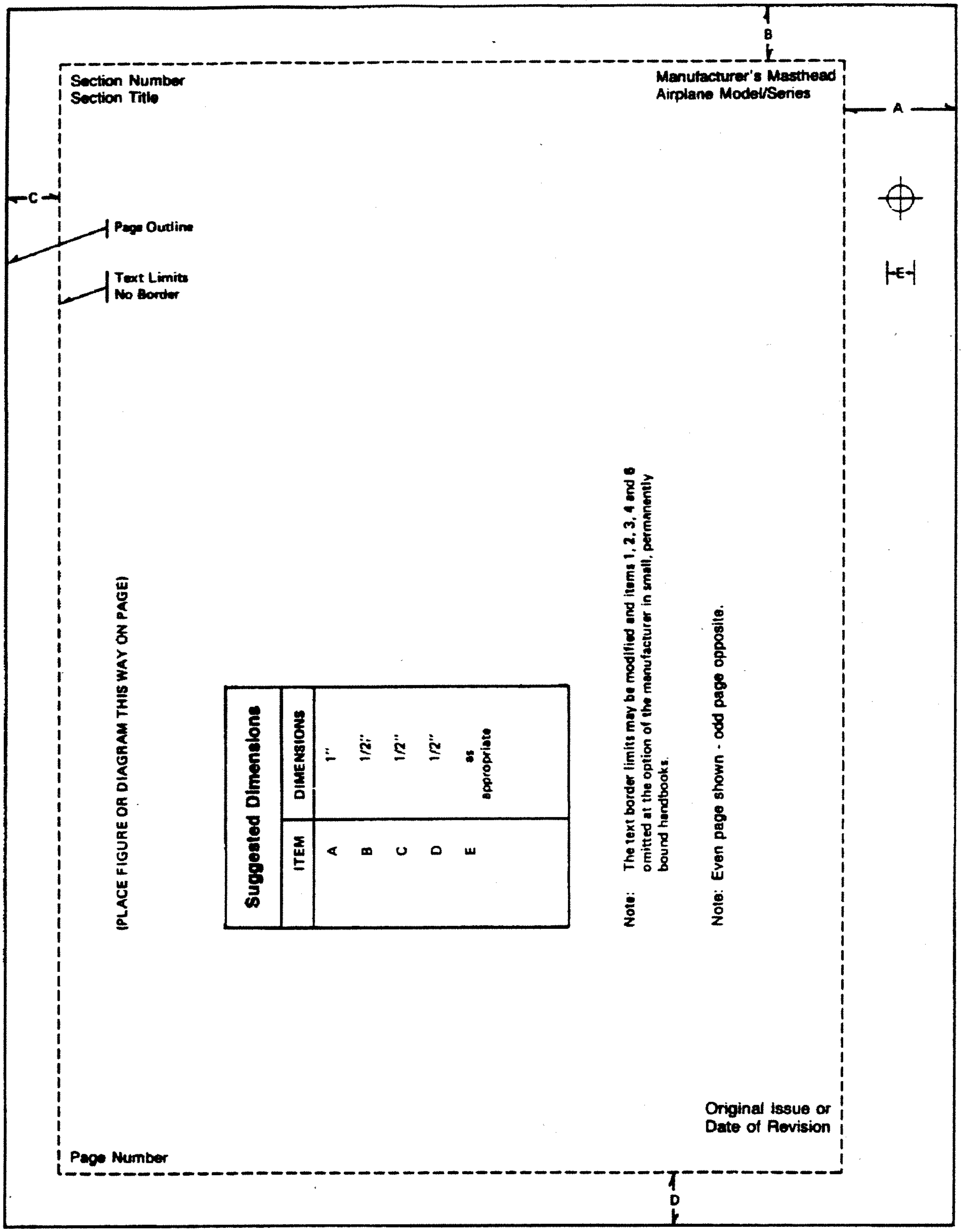


Figure 0-3
Suggested Horizontal Page Layout

© 1996 General Aviation Manufacturers Association

Manufacturer's Masthead
Airplane Model/Series

Section Number
Section Title

PILOT'S OPERATING HANDBOOK

LOG OF REVISIONS

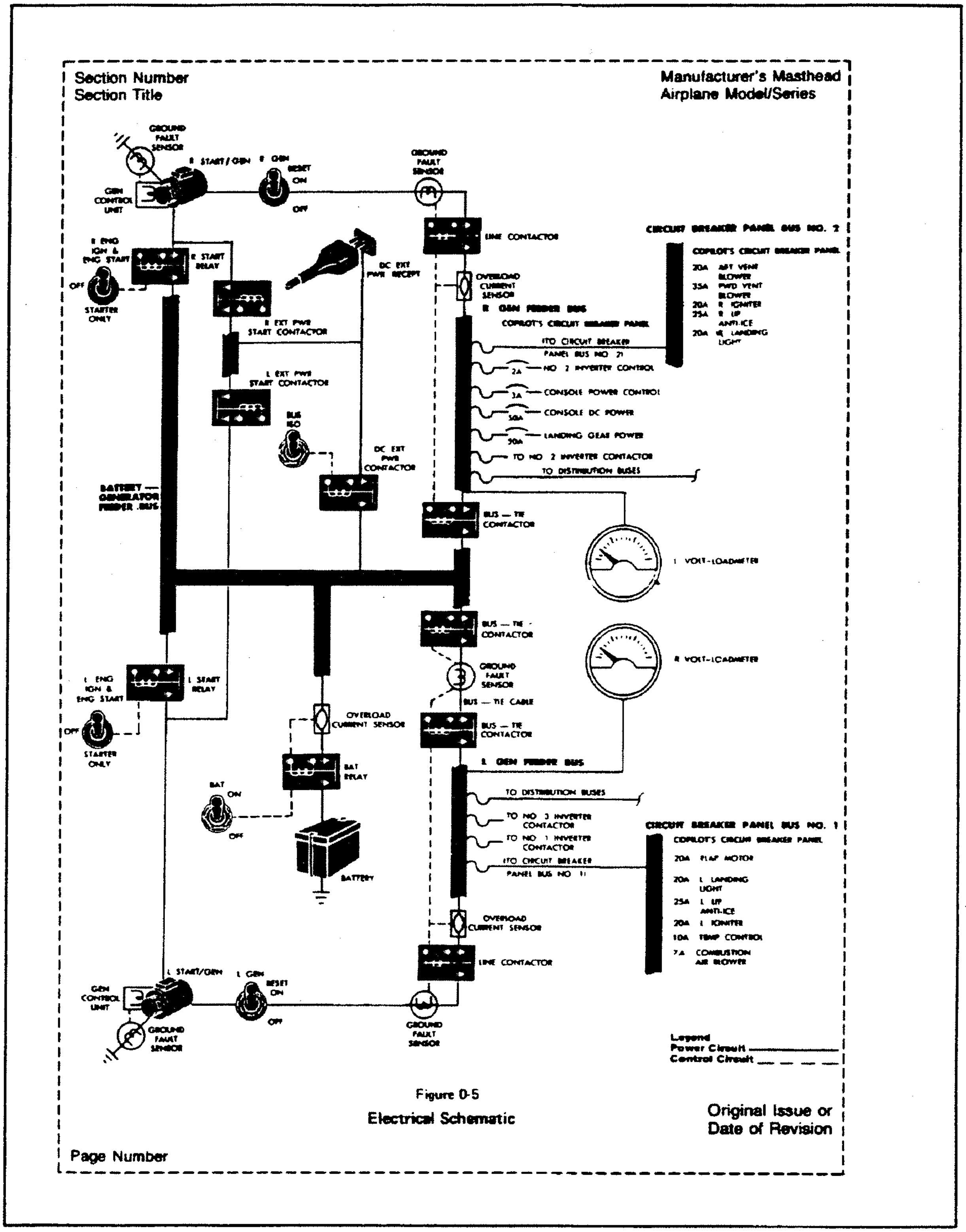
Revision Number and Date	Revised Pages	Description of Revision

Original Issue or
Date of Revision

Page Number

Figure 0-4
Suggested Log of Revisions

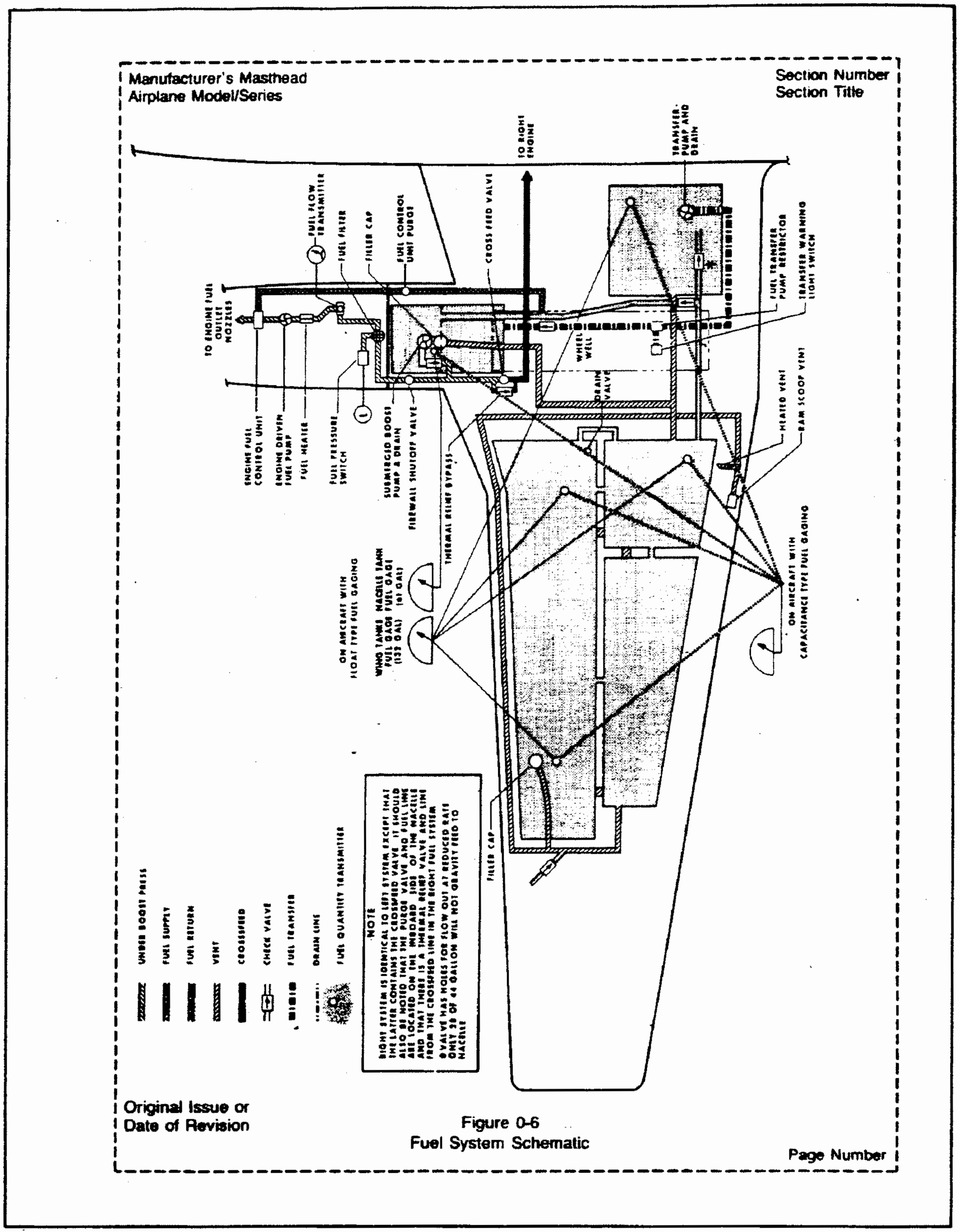
© 1996 General Aviation Manufacturers Association



Page

Figure 0-5
Suggested Vertical Schematic

© 1996 General Aviation Manufacturers Association



Layout

Figure 0-6
Fuel System Schematic

© 1996 General Aviation Manufacturers Association

SECTION 1

GENERAL

TABLE OF CONTENTS

Paragraph		Page
1.1	General	1-1
1.3	Introduction	1-1
1.5	Three View Drawings	1-1
1.11	Required Descriptive Data	1-1
1.13	Engine(s)	1-1
1.15	Propeller(s)	1-1
1.17	Fuel	1-1
1.19	Oil	1-2
1.21	Maximum Certified Weights	1-2
1.23	Typical Airplane Weights	1-2
1.25	Cabin & Entry Dimensions	1-2
1.27	Baggage Space & Entry Dimensions	1-2
1.29	Specific Loadings	1-2
1.31	Symbols, Abbreviations & Terminology	1-2
1.41	Conversion to Metric System	1-6

SECTION 1

GENERAL

1.1 General

Section 1 of the Pilot's Operating Handbook shall present basic data and information of general interest to the pilot which is useful in loading, sheltering, handling, and routine preflight checking of the airplane. In addition, it shall provide definitions or explanations of symbols, abbreviations, and terminology used in the Handbook. The selection of data by the Handbook producer, to be included in this Section, shall be governed by the concepts contained in the Preface of this Specification.

1.3 Introduction

The introduction shall include a brief outline of the Handbook's content, organization, method of usage and the following statement:

THIS HANDBOOK INCLUDES THE MATERIAL REQUIRED TO BE FURNISHED TO THE PILOT BY THE FEDERAL AVIATION REGULATIONS AND ADDITIONAL INFORMATION PROVIDED BY THE MANUFACTURER AND CONSTITUTES THE FAA APPROVED AIRPLANE FLIGHT MANUAL.

1.5 Three View Drawing

The airplane general arrangement shall be illustrated with a scale line drawing consisting of plan, side and front views presented in a vertical sequence upon a single page. Principal dimensions, particularly those useful for handling and sheltering the airplane, shall be shown upon the drawing. These dimensions include, as applicable:

(a) Wing Span
(b) Maximum Height
(c) Overall Length
(d) Wheel Base Length
(e) Main Landing Gear Track Width
(f) Maximum Propeller Diameter
(g) Propeller Ground Clearance
(h) Minimum Turning Radius
(i) Wing Area

1.11 Required Descriptive Data

Descriptive Data shall be supplied for standard and optional engine and propeller installations and fuel and oil systems. The data may be supplemented by brief descriptions of additional characteristics or features if desired. The Handbook shall include the information outlined in paragraphs 1.13 through 1.29, as applicable to the airplane.

1.13 Engine(s)

(a) Number of Engines
(b) Engine Manufacturer
(c) Engine Model Number
(d) Engine Type, for Example:
Reciprocating Engines
Normally aspirated or Turbocharged
Direct Drive or Geared
Air or Liquid Cooled
Horizontally Opposed or Radial
Number of Cylinders
Displacement
Turbopropeller Engines
Single Shaft or Multiple Shaft
Compressor Stages and Types
Combustion Chamber Type
Turbine Stages and Type
(e) Horsepower Ratings and Engine (or Propeller) Rotational Speed
(1) Takeoff Power
(2) Maximum Continuous Power
(3) Maximum Normal Operating Power
(4) Maximum Climb Power
(5) Maximum Cruise Power

Note: Horsepower ratings shall be in terms of horsepower for static, sea level, standard day conditions.

1.15 Propeller(s)

(a) Number of Propellers
(b) Propeller Manufacturer
(c) Propeller Model Number
(d) Number of Blades
(e) Propeller Diameter
(f) Propeller Type, for Example:
Fixed Pitch or Constant Speed
Full Feathering
Reversible
Hydraulic or Electrically Actuated
Pitch Range

© 1996 General Aviation Manufacturers Association

1.17 Fuel

(a) Fuel Grade or Specification, (including color), alternate fuels and approved additives
(b) Total Capacity
(c) Usable Fuel

1.19 Oil

(a) Oil Grade or Specification
(b) Viscosity Recommended for Various Average Air Temperature Ranges
(c) Total Oil Capacity
(d) Drain and Refill Quantity
(e) Oil Quantity Operating Range

1.21 Maximum Certificated Weights

(a) Maximum Ramp Weight (if applicable)
(b) Maximum Takeoff Weight
(c) Maximum Landing Weight
(d) Maximum Zero Fuel Weight (if applicable)
(e) Maximum Weight(s) in Baggage Compartment(s)

1.23 Typical Airplane Weights

Weights corresponding to the airplane as offered with typical seating and interior, avionics, accessories, standard equipment and fixed ballast, and the typical empty weight and maximum useful load based on this weight.

1.25 Cabin and Entry Dimensions

(a) Cabin Width (Maximum)
(b) Cabin Length (Maximum)
(c) Cabin Height (Maximum)
(d) Entry Width (Minimum)
(e) Entry Height (Minimum)
(f) Sill Height (Maximum)
(g) Other dimensions useful in determining what may be loaded.

1.27 Baggage Spaces and Entry Dimensions

Baggage Space or Compartment

(a) Compartment Width
(b) Compartment Length
(c) Compartment Height
(d) Compartment Volume
(e) Entry Width (Minimum)
(f) Entry Height (Minimum)
(g) Other dimensions useful in determining what may be loaded.

1.29 Specific Loadings

Wing and power loading, based on the Maximum Takeoff Weight of Paragraph 1.21(b) and the Takeoff Horsepower Rating of Paragraph 1. 13(e)(1) and the Wing Area of Paragraph 1.5(i).

1.31 Symbols, Abbreviations and Terminology

Define symbols, abbreviations and terminology necessary for the clear understanding and precise use of the information presented in various sections of the Handbook. Definitions should emphasize operational significance when possible.

The following guidelines shall be applied:

1. Define all abbreviations used or referred to in the Handbook.
2 Define any special terminologies used in the Handbook with emphasis on those which could be misused or misunderstood.
3. Definitions should be worded as simply as possible and must conform with the use of the defined terms in the Handbook.
4. Definitions shall be consistent with definitions contained in the Federal Aviation Regulations.

(a) *General Airspeed Terminology and Symbols*

CAS	*Calibrated Airspeed* means the indicated speed of an aircraft, corrected for position and instrument error. Calibrated airspeed is equal to true airspeed in standard atmosphere at sea level.
KCAS	Calibrated Airspeed expressed in "knots".
GS	*Ground Speed* is the speed of an airplane relative to the ground.
IAS	*Indicated Airspeed* is the speed of an aircraft as shown in the airspeed indicator when corrected for instrument error. IAS values published in this Handbook assume zero instrument error.
KIAS	Indicated Airspeed expressed in "knots".
M	*Mach Number* is the ratio of true airspeed to the speed of sound.
TAS	*True Airspeed* is the airspeed of an airplane relative to undisturbed air which is the CAS corrected for altitude, temperature and compressibility

© 1996 General Aviation Manufacturers Association

V_A — *Maneuvering Speed* is the maximum speed at which application of full available aerodynamic control will not overstress the airplane.

V_{FE} — *Maximum Flap Extended Speed* is the highest speed permissible with wing flaps in a prescribed extended position.

V_{LE} — *Maximum landing Gear Extended Speed* is the maximum speed at which an aircraft can be safely flown with the landing gear extended.

V_{LO} — *Maximum Landing Gear Operating Speed* is the maximum speed at which the landing gear can be safely extended or retracted.

V_{MCA} — *Air Minimum Control Speed* is the minimum flight speed at which the airplane is directionally and laterally controllable, determined in accordance with the Federal Aviation Regulations. Airplane certification conditions include one engine becoming inoperative and windmilling (or, in airplanes with autofeathering devices, feathered), not more than a 5° bank toward the operative engine, takeoff power on the operative engine, landing gear up, flaps in the takeoff position, and the most critical C.G.

V_{MO} M_{MO} — *Maximum Operating Limit Speed* is the speed limit that may not be deliberately exceeded in normal flight operations. V is expressed in knots and M in Mach Number

V_{NE} M_{NE} — *Never Exceed Speed* or Mach Number is the speed limit that may not be exceeded at any time.

V_{NO} — *Maximum Structural Cruising Speed* is the speed that should not be exceeded except in smooth air and then only with caution.

V_S — *Stalling Speed* or the minimum steady flight speed at which the airplane is controllable.

V_{SO} — *Stalling Speed* or the minimum steady flight speed at which the airplane is controllable in the landing configuration.

V_{SSE} — *Intentional One Engine Inoperative Speed* is the minimum speed, selected by the manufacturer, for intentionally rendering one engine inoperative, inflight, for pilot training.
Note: V_{SSE} is predicated upon the maintenance of conservative controllability margins when one engine is suddenly, intentionally rendered inoperative. Its selection shall be based upon the characteristics of the specific airplane to which it applies. However, in no case may it be lower than 1.05 V_{MCA}.

V_X — *Best Angle-of-Climb Speed* is the airspeed which delivers the greatest gain of altitude in the shortest possible horizontal distance.

V_Y — *Best Rate-of-Climb Speed* is the airspeed which delivers the greatest gain in altitude in the shortest possible time.

(b) Meteorological Terminology

ISA — *International Standard Atmosphere* in which

(1) The air is a dry perfect gas;
(2) The temperature at sea level is 15° Celsius (59° Fahrenheit);
(3) The pressure at sea level is 29.92 inches h g.(1013.2 mb);
(4) The temperature gradient from sea level to the altitude at which the temperature is -56.5°C (-69.7°F) is - 0.00198°C (- 0.003564°F) per foot and zero above that altitude.

OAT — Outside Air Temperature is the free air static temperature, obtained either from inflight temperature indications or ground meteorological sources, adjusted for instrument error and compressibility effects.

© 1996 General Aviation Manufacturers Association

Indicated Pressure Altitude	The number actually read from an altimeter when the barometric subscale has been set to 29.92 inches of mercury (1013.2 mb).
Pressure Altitude	Altitude measured from standard sea level pressure (29.92 in. hg.) by a pressure or barometric altimeter. It is the indicated pressure altitude corrected for position and instrument error. In this Handbook, altimeter instrument errors are assumed to be zero.
Station Pressure	Actual atmospheric pressure at field elevation.
Wind	The wind velocities recorded as variables on the charts of this Handbook are to be understood as the headwind or tailwind components of the reported wind.

(c) *Power Terminology*

Include, as applicable, the following definitions or explanations of terms. The definitions provided are examples. The definitions used in a particular Handbook should be appropriate for that particular airplane or installation.

Takeoff Power	The maximum power permissible for takeoff (may be time limited).
Maximum Continuous Power (MCP)	(1) (for multi-engine aircraft) The maximum power for one engine inoperative, abnormal or emergency operations.
Maximum Continuous Power (MCP)	(2) (for single-engine aircraft) Continuous The maximum power for abnormal or emergency operations.
Maximum Normal Operating Power (MNOP)	The maximum power for all normal operations (except takeoff). This power may be the same as Maximum Continuous Power.
Cruising Climb Power	The power (not to exceed MNOP) recommended to operate the airplane in a cruise climb (a continuous, gradual climb) profile.
Maximum Cruise power	The maximum power (not to MNOP) recommended for cruise

Flight Idle Power	The power required to run an engine, in flight, at the lowest speed that will ensure satisfactory engine operation and airplane handling characteristics
Ground Idle Power	The power required to run an engine on the ground, as slowly as possible, yet sufficient to ensure satisfactory engine, engine accessory, and airplane operation with a minimum of thrust.
Reverse Thrust	The thrust of the propeller directed opposite the usual direction, thereby producing a braking action.
Zero Thrust	The absence of appreciable thrust, in either direction.

(d) *Engine Controls and Instruments*

Include, as applicable, definitions, descriptions or explanations of the following terms or components. The definitions, descriptions and explanations provided are examples. Those used in a particular Handbook should be appropriate for that particular airplane or installation.

Throttle or Power Control Lever	The lever used to control engine power, from the lowest through the highest power, by controlling propeller pitch, fuel flow, engine speed, or any combination of these
Propeller Control	The lever used to select a propeller speed. For some airplanes, in the maximum decrease rpm position, it may feather the propeller. It may also activate the fuel cut off to that engine.
Mixture Control	On reciprocating (piston) engine powered airplanes, the mixture control provides a mechanical linkage with the mixture control valve of the carburetor, or the fuel control unit of fuel injection engines, to control the size of the fuel feed aperture, and thus, the air/fuel mixture. It is also a primary means to shut down the engine

© 1996 General Aviation Manufacturers Association

Condition Lever	On some turbopropeller powered airplanes, the condition lever is the primary control for starting and stopping the engine. On others, it is the primary control used to set engine and propeller speed. On some engines, it coordinates other power management system functions. It may also be used to feather or unfeather the propeller.
EGT Gauge	The exhaust gas temperature indicator, on piston engine powered airplanes, is the instrument used to identify the lean fuel flow mixtures for various power settings.
TIT, ITT or TTI Gauge	A temperature measuring system that senses gas temperature in the turbine section of the engine. On some engines, it indicates thrust or power.
Tachometer	An instrument that indicates rotational speed. On reciprocating engine installations, the speed is usually shown as propeller revolutions per minute (RPM). Turbine engine tachometers usually measure speed as a percentage of the nominal maximum speed of the turbine(s), unless specifically referred to the propeller
Torquemeter	An indicating system that displays the output torque available on the propeller shaft. Torque may be shown in dimensional terms, such as foot-pounds, or in reference terms, such as a percentage or a pressure.
Propeller Governor	The device that regulates the rpm of the engine/propeller by increasing or decreasing the propeller pitch, through a pitch change mechanism in the propeller hub.
Beta Range	On turbine powered aircraft using fully reversing propellers, this is the range of propeller blade angle movement not controlled by a governor and the propeller control lever. In this range, the blade pitch angle is scheduled by power lever movement and the constant propeller speed mechanism is blocked out. On some airplanes, a portion of the beta range may be used for drag control on approach, and on others, it is used only on the ground for taxi and reverse thrust control.

(e) *Airplane Performance and Flight Planning Terminology*

Include definitions necessary for the pilot to use airplane performance information effectively. The following definitions should be included as applicable.

Climb Gradient	The demonstrated ratio of the change in height during a portion of a climb, to the horizontal distance traversed in the same time interval
Demonstrated Crosswind Velocity	The demonstrated crosswind velocity is the velocity of the crosswind component for which adequate control of the airplane during takeoff and landing was actually demonstrated during certification tests. The value shown may or may not be limiting. (Whether or not the value shown is limiting should be stated.)
Accelerate-Stop Distance	The distance required to accelerate an airplane to a specified speed and, assuming failure of an engine at the instant that speed is attained, to bring the airplane to a stop
Accelerate-Go Distance	The distance required to accelerate an airplane to a specified speed and, assuming failure of an engine at the instant that speed is attained, continue take-off on the remaining engine(s) to a height of 50 feet.

© 1996 General Aviation Manufacturers Association

MEA	Minimum enroute IFR altitude.
Route Segment	A part of a route. Each end of that part is identified by: (1) a geographical location; or (2) a point at which a definite radio fix can be established.

(f) *Weight and Balance*

Include definitions of terms used in weight and balance descriptions and computations; such as:

Reference Datum	An imaginary vertical plane from which all horizontal distances are measured for balance purposes.
Station	A location along the airplane fuselage usually given in terms of distance from the reference datum.
Arm	The horizontal distance from the reference datum to the center of gravity (C.G.) of an item.
Moment	The product of the weight of an item multiplied by its arm. (Moment divided by a constant is used to simplify balance calculations by reducing the number of digits.)
Center of Gravity (C.G.)	The point at which an airplane would balance if suspended. Its distance from the reference datum is found by dividing the total moment by the total weight of the airplane.
C.G. Arm	The arm obtained by adding the airplane's individual moments and dividing the sum by the total weight.
C . G. Limits	The extreme center of gravity locations within which the airplane must be operated at a given weight
Usable Fuel	Fuel available for flight planning.
Unusable Fuel	Fuel remaining after a runout test has been completed in accordance with governmental regulations.
Standard Empty Weight	Weight of a standard airplane including unusable fuel, full operating fluids and full oil.
Basic Empty Weight	Standard empty weight plus optional equipment.
Payload	Weight of occupants, cargo and baggage.
Useful Load	Difference between take off weight, or ramp weight if applicable, and basic empty weight.
Maximum Ramp Weight	Maximum weight approved for ground maneuver. (It includes weight of start, taxi and run up fuel.)
Maximum Takeoff Weight	Maximum weight approved for the start of the takeoff run.
Maximum Landing Weight	Maximum weight approved for the landing touchdown.
Maximum Zero Fuel Weight	Maximum weight exclusive of usable fuel

1.4 Conversion to Metric System

At the option of the manufacturer, factors for conversion of dimensional, quantity and performance units to the metric system may be included.

© 1996 General Aviation Manufacturers Association

SECTION 2

LIMITATIONS

TABLE OF CONTENTS

Paragraph		Page
2.1	General	2-1
2.3	Airspeed Limitations	2-1
2.5	Airspeed Indicator Markings	2-3
2.7	Power Plant Limitations (Reciprocating Engines)	2-4
2.9	Power Plant Limitations (Turbopropeller Engines)	2-4
2.12	Miscellaneous Instrument MarKings	2-5
2.13	Weight Limits	2-5
2.15	Center of Gravity Limits	2-5
2.17	Maneuver Limits	2-6
2.19	Flight Load Factor Limits	2-6
2.21	Flight Crew Limits	2-6
2.23	Kinds of Operations Limits	2-6
2.25	Fuel Limitations	2-6
2.27	Climb Condition Limits	2-6
2.29	Maximum Operation Altitude Limit	2-6
2.31	Outside Air Temperature Limit	2-6
2.33	Cabin Pressurization Limit	2-6
2.35	Maximum Passenger Seating Limit	2-6
2.37	Systems & Equipment Limit	2-6
2.39	Other Limitations	2-6
2.41	Placards	2-6

SECTION 2

LIMITATIONS

2.1 General

This Section of the Pilot's Operating Handbook shall contain only those limitations required by regulation or necessary for safe operation of the airplane and approved by the regulatory authority. It shall present the various operating limitations, instrument markings, color coding and basic placards necessary for the safe operation of the airplane, its powerplant(s), systems and equipment. The content of this Section shall be guided by the following considerations:

(a) As only approved limitations may be included in this Section, an introductory statement to this effect shall be contained in a prefatory note or the opening paragraph. For example:

"The limitations included in this Section are approved by the Federal Aviation Administration."

(b) Limitations associated with optional systems or equipment may be included in this Section or in *Section 9, Supplements*. If limitations are incorporated in Section 9, this Section shall contain a note referring the reader to that section for limitations on the optional systems or equipment.

(c) The specific content of this Section shall conform to the applicable Federal Aviation Regulations (FAR's) governing the certification and operation of the particular airplane. Though this Section of this Specification often references Part 23 of the Federal Aviation Regulations (FAR 23), the references are *for illustration purposes only*. The applicable regulations for any specific airplane, which may differ from the referenced FAR, must be followed.

2.3 Airspeed Limitations

Provide airspeed limitations and the operational significance of such limitations. The name, symbol, value in knots, CAS, and IAS (assuming zero instrument error), and the significance of each airspeed, shall also be provided. Where the airspeed values may be applicable to more than one configuration, the more conservative IAS value shall be used. (See Figure 2-1)

© 1996 General Aviation Manufacturers Association

SPEED	CAS	IAS	REMARKS
Maneuvering Speed V_A (Knots)			(Specify weight) Do not make full or abrupt control movements above this speed.
Maximum Flap Extended Speed V_{FE} (Knots)			(Specify flap setting) Do not exceed this speed with a given flap setting.
Maximum Landing Gear Operating Speed V_{LO} (Knots)			Do not extend or retract landing gear above this speed
Maximum Landing Gear Extended Speed V_{LE} (Knots)			Do not exceed this speed with landing gear extended.
Air Minimum Control Speed V_{MCA}			This is the minimum flight speed at which the airplane is directionally and laterally controllable, determined in accordance with the Federal Aviation Regulations.
**Maximum Operating Speed Limit V_{MO} (Knots) M_{MO} (Mach #)			Do not exceed this airspeed or Mach Number in any operation.
*Never Exceed Speed V_{NE} (Knots) M_{NE} (Mach #)			Do not exceed this speed or Mach Number in any operation.
*Maximum Structural Cruising Speed V_{NO} (Knots) M_{NO} (Mach #)			Do not exceed this speed or Mach Number except in smooth air and then only with caution.

Add any other speed limitations
*reciprocating powered airplanes only
** turbine powered airplanes only

Figure 2-1
Airspeed Limitations

© 1996 General Aviation Manufacturers Association

2.5 Airspeed Indicator Markings

An explanation of airspeed indicator markings, including the color coding, shall immediately follow the presentation on airspeed limitations. The use of line drawings or photographs to show the markings is encouraged. (See Figure 2-2)

MARKINGS	IAS VALUE OR RANGE	SIGNIFICANCE
Red Line		Airspeed Control Speed (Multi-Engine Only)
White Arc		Full Flap Operating Range. Lower limit is maximum weight stalling speed in landing configuration. Upper limit is maximum speed permissible with flaps extended
Blue Line		One Engine Inoperative Best Rate of Climb (Specify Weight and Altitude if Applicable}
Green Arc		Normal Operating Range. Lower Limit is maximum weight stalling speed with flaps and landing gear (if retractable) retracted. Upper limit is maximum structural cruising speed.
Yellow Arc		Operations must be conducted with caution and only in smooth air.
Red Line		Maximum speed for all operations

Figure 2-2
Airspeed Indicator Markings

© 1996 General Aviation Manufacturers Association

2.7 Power Plant Limitations (Reciprocating Engines)

Provide the following powerplant limitations and data. as applicable:

(a) Number of Engines
(b) Engine Manufacturer
(c) Engine Model Number
(d) Engine Operating Limits for Takeoff Power, Maximum Continuous Power, and Maximum Normal Operating Power, as applicable.
(e) Oil Pressure (Minimum and Maximum)
(fl Fuel Pressure (Minimum and Maximum)
(g) Other (Such as Ice Protection System Time Limit)
(h) Fuel Grade or Specification. including color
(i) Oil Grade or Specification
U) Number of Propellers
(k) Propeller Manufacturer
(l) Propeller Hub and Blade Model Numbers
(m) Propeller Diameter (Minimum and Maximum)
(n) Propeller Blade Angles at Specified Radius or Station
(o) Propeller Operating Limits
  (l) Rotational Speed Restrictions
    Note: The Federal Aviation Regulations require the use of 'maximum continuous power", during certification of an airframe and engine combination, to show compliance with certain standards. When the airplane manufacturer selects a "maximum continuous power less than the rated "maximum continuous power listed in the Engine Type Data Sheet. the maximum continuous power listed in the Airplane Type Data Sheet is used to show compliance with the applicable airworthiness standards and is the value shown in the Pilot's Operating Handbook.

2.9 Powerplant Limitations (Turbine Engines)

Provide the following powerplant limitations and data , as applicable:

(a) Number of Engines
(b) Engine Manufacturer
(c) Engine Model Number
(d) Engine Operating Limits shall be provided for the following applicable operations:
  (I) Takeoff
  (2) Maximum Continuous
  (3) Maximum Climb
  (4) Maximum Cruise
  (5) Normal Cruise
  (6) Idle (Flight and/or Ground)
  (7) Maximum Reverse
  (8) Acceleration
  (9) Starting
  (10) Other
(e) Operating Limits associated with the type of Operation specified by (d) above, may include:
  (l) Maximum Power Indication (Torque, Shaft Horsepower)
  (2) Maximum Shaft Rotational Speed
  (3) Maximum Gas Temperature
  (4) Maximum Time for Specified Operation
  (5) Maximum Oil Temperature
  (6) Other
(f) Oil Pressure (Minimum and Maximum)
(g) Fuel Pressure (Minimum and Maximum)
(h) Other (Such as Generator or Alternator Limits)
(i) Fuel Grade or Specification and Approved Fuel Additives (Preferred and alternate, with any Limitations on use of Aviation Gasoline)
(j) Oil Grade or Specification and Approved Oil Additives
(k) Number of Propellers
(l) Propeller Manufacturer
(m) Propeller Hub and Blade Model Numbers
(n) Propeller Diameter (Minimum and Maximum)
(o) Propeller Blade Angles and Specified Radius or Station
(p) Propeller Operating Limits
  (l) Rotational Speed Restrictions

© 1996 General Aviation Manufacturers Association

2.11 Powerplant Instrument Markings

An explanation of powerplant instrument markings shall immediately follow the presentation on powerplant limitations. The use of line drawings or photographs to show the markings is encouraged. (See Figure 2-3.)

INSTRUMENT	Red Line	yellow Arc	Green Arc	Yellow Arc	Red Line
	MINIMUM LIMIT	CAUTIO N RANGE	NORMAL OPERATIN G	CAUTION OR TAKEOFF	MAXIMUM LIMIT
POWER INDICATOR					
TACHOMETER					
MANIFOLD PRESSURE					
GAS TEMPERATURE					
OIL TEMPERATURE					
CYLINDER HEAD TEMPERATURE					
COOLANT TEMPERATURE					
FUEL PRESSURE					
OIL PRESSURE					
OTHER (As Generator)					

Figure 2-3
Power Plant Instrument Markings

2.12 Miscellaneous Instrument Markings

Provide limitations and markings for miscellaneous instruments, such as a pneumatic pressure gauge or a vacuum/pressure instrument gauge, as appropriate.

2.13 Weight Limits

Maximum Certificated Airplane Weights shall be started as required. If appropriate, reference shall be made to data in Section 5 (Performance) of the Pilot's Operating Handbook concerning the Maximum Takeoff Weight as limited by performance. If certificated in more than one category, the weights, with any restrictions, shall be given for each category. The following weights shall be presented if applicable:

(a) *Maximum Ramp Weight*
(b) *Maximum Takeoff Weight*
(c) *Maximum Landing Weight*
(d) *Maximum Zero Weight*
(e) *Maximum Weight(s) in Baggage Compartment(s)*

2.15 Center of Gravity Limits

Allowable Forward and Aft Center of Gravity Limits shall be presented as required. These limits shall be presented for each Category for which the aircraft is certificated. These limits shall be specified over the range from Minimum to Maximum Takeoff Weight, landing gear extended, and shall include the following supporting information:

(a) Guidance as to the proper method of interpolating tabular statements of the center of gravity limits for various weights
(b) A definition of the Reference Datum relative to the airframe in terms convenient for operational use
(c) The length and location of the leading edge of the Mean Aerodynamic Cord, if used
(d) If removable ballast is used, the location and amount of the ballast weight, and any cautionary information required

© 1996 General Aviation Manufacturers Association

2.17 Maneuver Limits
The following information on maneuvers appropriate to the Airplane Category shall be given:
(a) A Statement of Authorized Maneuvers and Appropriate Entry Speeds
(b) A Statement of Unauthorized Maneuvers
(c) A Statement that the airplane is Approved for Spins, Unapproved for Spins, or is characteristically incapable of spinning

2.19 Flight Load Factor Limits
The limit maneuvering load factors, in g units of acceleration, for clean cruise and landing configurations, shall be given. The negative g limit, flaps up, should be given for aircraft approved for spinning or aerobatics.

2.21 Flight Crew Limits
Provide a statement of the minimum crew and the function of each flight crew member, if more than one is required.

2.23 Kinds of Operations
Provide, at an appropriate place in this Section, a statement of the kinds of operations allowed when listed operable equipment is installed. If any installed equipment affects an operating limitation, the equipment shall be listed and identified as to operational function.

2.25 Fuel Limitations
Total capacity and usable fuel shall be stated and, if the unusable fuel exceeds the limits of FAR 23, information shall be given identifying the quantities unusable in flight.

2.27 Climb Condition Limits
For turbopropeller powered airplanes only, the established temperatures and corresponding altitude limits of powerplant components and engine fluids shall be stated.

2.29 Maximum Operating Altitude Limit
For pressurized airplanes and turbosupercharged or turbopropeller powered airplanes, the Maximum Altitude Limits shall be stated.

2.31 Outside Air Temperature Limits
For turbopropeller powered airplanes only, the Minimum and Maximum Outside Air Temperature Limits shall be presented as a function of pressure altitude.

2.33 Cabin Pressurization Limit
Data shall be presented stating the Normal and Maximum Cabin Operating Differential Pressure. Restrictions on use of cabin pressurization during takeoff, landing, or in flight shall be noted, if applicable.

2.35 Maximum Passenger Seating Limits
Any limits on Maximum Passenger Seating, by number of passengers or specific restrictions on seat occupancy, shall be stated.

2.37 Systems and Equipment Limits
Limits on any Airplane systems or equipment shall be provided. For example, limits may be necessary in connection with electrothermal elements used in ice protection systems, or in battery temperatures. Provide limitations necessary for the safe operation of optional systems or equipment in this Section or in Section 9, Supplements, or in both.

2.39 Other Limitations
Provide a statement of any limitation required by regulation or permitted or approved by the regulatory authority, not specifically covered in this Section.

2.41 Placards
Operating Placards shall be listed or illustrated.

© 1996 General Aviation Manufacturers Association

SECTION 3

EMERGENCY PROCEDURES

TABLE OF CONTENTS

Paragraph			Page
3.1	General		3-1
3.3	Airspeeds for Emergency Operations		3-1
3.5	Emergency Procedures Check List		3-1
3.7	Amplified Emergency Procedures		3-1
3.9	Emergencies		3-2
	a.	Engine Failure	3-2
	b.	Air Start	3-2
	c.	Smoke and Fire'	3-2
	d.	Emergency Descent	3-2
	e.	Glide	3-2
	f.	Landing Emergencies	3-2
	g.	System Emergencies	3-2
	h.	Spin	3-2
	i.	Other	3-3

SECTION 3

EMERGENCY PROCEDURES

3.1 General

This Section of the Pilot's Operating Handbook shall' clearly and precisely describe the recommended procedures for coping with various types of emergencies or critical situations. Procedures for handling malfunctions or other abnormalities that are not of emergency nature, or involve a potential emergency that may be deferred, may be included in this Section or in optional Section 3A, Abnormal Procedures. The incorporation of an Abnormal Procedures Section in Handbooks is encouraged.

The subject matter and subject headings of this Section of a Handbook shall conform to the order and headings of paragraphs in this Section of the Specification.

The material within subparagraphs of a Handbook may follow the order of material within subparagraphs of this Section of the Specification or may be arranged to suit a particular type or model of airplane. In addition, Handbook writers shall consider the following objectives:

(a) Airspeeds used in the Emergency Procedures shall be specified in terms of Indicated Airspeed, assuming zero instrument error, in order to make the information as directly usable as possible.
(b) The Emergency Procedures Section shall include at the beginning a check list with regard to order of action when sequence is essential to safety.
(c) The check list may be followed by amplified procedures to provide pilots with a better understanding of the reasons for actions in the short form check list.
(d) Emergency procedures associated with optional systems or equipment may be included in this Section or in Section 9, Supplements. If emergency procedures are incorporated in Section 9, this Section shall contain a note referring the reader to that Section for emergency procedures on the optional systems or equipment.

3.3 Airspeeds for Emergency Operations

(a) Required and recommended airspeeds (and the configuration of the airplane for which the airspeeds apply) deemed likely to enhance safety of operation during an emergency shall be listed near the beginning of this Section or in the Emergency Procedures Check List, or both. For example, this list will include speeds such as the maneuvering airspeed(s) and the speed(s) for maximum gliding distance.
(b) In addition, for multi-engine airplanes, include the one engine inoperative best rate of climb speed (V_{YSE}), the one engine inoperative best angle of climb speed (V_{XSE}), and the air minimum control speed (V_{MCA}) with the critical engine inoperative. For these speeds, provide the significant conditions under which they may be obtained (aircraft weighty, atmospheric conditions, etc.).

3.5 Emergency Procedures Check List

The emergency procedures check list should be in concise, abbreviated form designed to remind pilots of items to check without providing details concerning the operation of any system.

The check list may be arranged by 'Challenge" and "Response" headings for two pilot aircraft or by "Item" and "Condition" headings for single pilot aircraft. Under either method, the item to be checked is listed with the desired condition stated. Key words or switch and lever positions are capitalized in the Condition Column.

EXAMPLE:

CHALLENGE OR ITEM	RESPONSE OR CONDITION
Battery Switch	OFF
Generator	OFF

The check list should be limited to the minimum number of items determined to be essential to aid the pilot in an emergency.

3.7 Amplified Emergency Procedures

The check list may be followed by additional information (amplified procedures) to provide pilots with a better understanding of the reasons for actions in the check list. The amplified procedures may also

© 1996 General Aviation Manufacturers Association

include additional procedures that a pilot would not reasonably be expected to refer to in resolving a given emergency. Discussion of emergency situations, the resolution of which are not amenable to check list format, may also be included.

3.9 Emergencies

3.9(a) Engine Failure

Procedures shall be provided for all airplanes for all cases of engine failure, including partial failure (partial power), during takeoff and in flight.

3.9(b) Air Start

Procedures shall be provided for starting the engine in flight and, in the event the engine does not start, for subsequent action(s).

3.9(c) Smoke and Fire

Procedures shall be provided for coping with cases of smoke and/or fire in the cabin or from an engine in the following flight phases:

(1) On the Ground
(2) During Takeoff
(3) In-Flight

3.9(d) Emergency Descent

Procedures shall be provided for making an emergency descent.

3.9(e) Glide

Procedures and information shall be provided for a gliding descent, including:

(1) The Recommended Airspeed
(2) The Associated Configuration
(3) The distance(s) from (a) specified height(s) above ground level that an airplane will glide, or the glide ratio in nautical miles per thousand feet.

3 .9(f) Landing Emergencies

Procedures shall be provided for the various landing emergencies, including:

(1) For all airplanes, forced landings under the following conditions:
  (A) Precautionary Landings
  (B) With a Flat Tire
  (C) With a Defective Landing Gear
  (D) With Power, Landing Gear Retracted
  (E) Without Power, Landing Gear Retracted
  (F) Ditching, for aircraft with extended overwater flight capability
  (G) Approach and landings with flaps retracted, if flapless landings require any special technique or if information is required by the certificating authority.
(2) For Multi-Engine Airplanes Only:
  (A) One Engine Inoperative Landing
  (B) One Engine Inoperative Go-Around
  (If this maneuver cannot be performed safely, a warning against attempting it shall be provided.)

3.9(g) System Emergencies

Procedures shall be provided for coping with emergencies involving the following systems, as applicable:

(1) Engine
(2) Supercharger/turbocharger or other augmentation
(3) Propeller
(4) Fuel
(5) Electrical
(6) Hydraulic
(7) Pneumatic
(8) Flight Controls
(9) Landing Gear
(10) Nose Wheel Steering
(11) Environmental
(12) Oxygen
(13) Ice Protection
(14) Emergency Exits
(15) Other

3.9(h) Spins

Handbooks for all single engine airplanes, other than for those airplanes which have been shown to be "characteristically incapable of spinning" shall contain procedures for recovery from spins. These procedures shall be in the Emergency Procedures Section for all airplanes except those in the acrobatic category. Spin recovery procedures for acrobatic airplanes may be included under Normal Procedures.

If the airplane has not been tested for spin characteristics and recovery methods, a discussion of prevention of spins and probable best recovery techniques will be included with the qualification that no tests were made and the recovery techniques are based on the best judgment of the manufacturer.

© 1996 General Aviation Manufacturers Association

Spin recovery procedures for multi-engine airplanes may be included at the option of the manufacturer. It should be noted that multi-engine airplanes have not been spun by the manufacturer, if such is the case.

3.9(i) Other

Emergency Procedures and other pertinent information necessary for safe operations shall be provided for emergencies peculiar to a particular airplane design, operating or handling characteristics

© 1996 General Aviation Manufacturers Association

SECTION 3A

ABNORMAL PROCEDURES

TABLE OF CONTENTS

Paragraph		Page
3A.1	General	3A-1
3A.3	Airspeeds for Abnormal Operations	3A-1
3A.5	Abnormal Procedures Check List	3A-1
3A.7	Amplified Abnormal Procedures	3A-2
3A.9	Abnormalities	3A-2

SECTION 3A

ABNORMAL PROCEDURES

3A. 1 General

This section of the Pilot's Operating Handbook shall clearly and precisely describe the recommended procedures for handling malfunctions of equipment, or other abnormalities, that are not of an emergency nature or involve a potential emergency that may be deferred. An example of a deferred emergency is a landing gear that does not respond properly to normal gear switch actions when there are no other malfunctions in the powerplant or other systems. A gear up emergency landing, if necessary can be deferred until after all other methods of lowering the gear have been unsuccessfully tried and a suitable landing area has been selected. Examples of less critical abnormal conditions include failure of some portion of the electrical system in day VFR conditions, failure of automatic pilots or wing levelers enroute, or failure of some, but not all, elements of the navigation and communication systems.

An "emergency" however, almost always involves a failure that requires immediate and rapid response, such as a total powerplant failure, fire or smoke, or rapid cabin decompression. The difference between an "emergency" and "abnormal" situation may also depend on the circumstances of flight, i.e., night or IFR versus day VFR, the presence of icing conditions, or the occurrence of multiple malfunctions.

Because differences in design and complexity of the various types and models of airplanes play a major role in deciding whether a specific malfunction is more appropriately listed under "emergency" or "abnormal" procedures, or whether an "Abnormal Procedures" section is desirable, the decision to include an "ABNORMAL PROCEDURES" Section, or provide only an "EMERGENCY PROCEDURES" Section, is left to the Handbook producer.

If an Abnormal Procedures Section is provided, the subject matter and subject headings of this Section of a Handbook shall conform to the order and headings of paragraphs in this Section of the Specification. The material within subparagraphs of a Handbook may follow the order of material within subparagraphs of this Section of the Specification or may be arranged to suit a particular type or model of airplane. In addition, Handbook writers shall consider the following objectives:

(a) Airspeeds used in this Section shall be specified in Indicated Airspeed, assuming zero instrument error, in order to make the information as directly usable as possible.
(b) The Abnormal Procedures Section shall include, at the beginning, a check list with regard to order of action when sequence is essential to safety.
(c) The Check List may be followed by amplified procedures to provide pilots with a better understanding of the reasons for actions in the check list.
(d) Abnormal procedures associated with optional systems or equipment may be included in this Section or in Section 9, Supplements. If Abnormal Procedures are incorporated in Section 9, this Section shall contain a note referring the reader to that Section for abnormal procedures on the optional systems or equipment.
(e) The exact content of the Abnormal Procedures Section shall be determined by each Handbook producer, considering the design features of each airplane.

3A. 3 Airspeeds for Abnormal Operations

Airspeeds (and the configuration of the airplane for which the airspeeds apply) deemed likely to enhance safety of operation during an abnormal situation shall be listed near the beginning of this Section or in the Abnormal Procedures Check List, or both.

3A.5 Abnormal Procedures Check List

The Abnormal Procedures Check List should be in concise, abbreviated form and designed to remind pilots of items to check without providing details concerning the operation of any system. The Check List may be arranged by "Challenge" and "Response" headings for two pilot aircraft or by "Item" and "Condition" headings for single pilot aircraft. Under either method, the item to be checked is listed with the desired condition stated. Key words or switch and

© 1996 General Aviation Manufacturers Association

lever positions are capitalized in the Condition column.

EXAMPLE:

CHALLENGE OR ITEM	RESPONSE OR CONDITION
Gear Selector	UP
Generator Trip Switches	PUSH

3A.7 Amplified Abnormal Procedures

The Check List may be followed by additional information (amplified procedures) to provide pilots with a better understanding of the reasons for actions in the Check List. In addition, or as an alternative, there may be a reference to Section 7, Description of the airplane and Its System or Section 9, Supplements.

3A.9 Abnormalities

The abnormalities to be included in this Section shall be determined by the Handbook producer, considering the following:

(a) Engine
(b) Propeller
(c) Fuel
(d) Electrical
(e) Hydraulic
(f) Pneumatic
(g) Flight Controls
(h) Landing Gear
(I) Nose Wheel Steering
(j) Environmental
(k) Oxygen
(l) Ice Protection
(m) Emergency Exits
(n) Other

© 1996 General Aviation Manufacturers Association

SECTION 4

NORMAL PROCEDURES

TABLE OF CONTENTS

Paragraph		Page
4.1	General	4-1
4.3	Airspeeds for Normal Operation	4-1
4.5	Normal Procedures Check List	4-1
4.7	Amplified Normal Procedures	4-1
4.9	Normal Procedures	4-2
	a. Preflight Inspection	4-2
	b. Before Engine Starting	4-2
	c. Use of External Power	4-2
	d. Engine Starting	4-2
	e. Before Taxiing	4-2
	f. Taxiing	4-2
	g. Before Takeoff	4-2
	h. Takeoff	4-2
	i. Climb	4-2
	j. Cruise	4-2
	k. Descent	4-2
	l. Before Landing	4-2
	m. Balked Landing	4-2
	n. After Landing	4-2
	o. Shutdown	4-2
	p. Postflight ELT	4-2
4.11	Environment Systems	4-2
4.13	Other Normal Procedures	4-2
4.15	Noise Characteristics	4-2
4.17	Procedures for Practice Demonstration of V_{MCA}	4-2
4.19	Fuel Conservation	4-2

SECTION 4

NORMAL PROCEDURES

4.1 General

This Section of the Pilot's Operating Handbook shall clearly and precisely describe the recommended procedures for the conduct of normal operations. Except as noted in paragraph 4.19, the subject matter and subject headings of this Section of the Handbook shall conform to the order and headings of paragraphs in this Section of the Specification.

The material within subparagraphs of Handbooks may follow the order of material within subparagraphs of this Section of the Specification or may be arranged to suit a particular type or model of airplane. In addition, Handbook writers shall consider the following objectives:

(a) Airspeeds used in this Section shall be specified in Indicated Airspeed, assuming zero instrument error, in order to make the information *as* directly usable as possible.
(b) The Normal Procedures Section shall include, at the beginning, a check list, with regard to order of action, when sequence is essential.
(c) The Check List may be followed by amplified procedures to provide pilots with more detail on, and better understanding of, the reasons for actions in the Check List.
(d) Normal procedures associated with optional systems or equipment may be included in this Section or in Section 9, Supplements. If normal procedures are incorporated in Section 9, this Section shall contain a note referring the reader to that Section for normal procedures on the optional systems or equipment.
(e) The exact content of the Normal Procedures Section shall be determined by the applicable regulations of the certificating authority and by the operating and design features of each particular airplane. All information required by FAR Part 23, or other applicable regulations, will be included.

4.3 Airspeeds for Normal Operations

The airspeeds which may enhance the safety of operations shall be provided as a preface to the Normal Procedures Section. The following speeds, with associated weight, atmospheric and other conditions, shall be given:

(a) The ALL Engines Recommended Climb Speed
(b) The ALL Engines Best Angle of Climb Speed
(c) ALL Engines Approach Speed
(d) Speeds for Transition to the Balked Landing Condition
(e) The Maximum Demonstrated Crosswind Velocity
(fl The Recommended Turbulent Air Penetration Speed
(g) Other airspeeds recommended by the manufacturer, such as Intentional One Engine Inoperative Speed.

4.5 Normal Procedures Check List

The normal procedures check list should be in concise, abbreviated form and designed to remind pilots of items to check without providing details concerning the operation of any system.

The Check List may be arranged by "Challenge" and "Response" headings for two pilot airplanes or by "Item" and "Condition" headings for single pilot airplanes. Under either method, the item to be checked is listed with the desired condition stated. Key words or switch and lever positions are capitalized in the Condition Column.

EXAMPLE:

CHALLENGE OR ITEM	RESPONSE OR CONDITION
Mixture	RICH
Generators	ON/CHECKED
Carburetor Heat	COLD

The Check List may also contain supplemental information pertinent to the operation of the airplane, such as performance data, optional equipment operation, etc., that the pilot might routinely use.

4.7 Amplified Normal Procedures

Additional information, to provide a more complete understanding of the items in the Normal Procedures Check List, in the order of this Check List. may be included in this Section immediately following the Check List. The Amplified Normal Procedures are not intended for routine use in flight, permitting substantial detail and explanation. For example, if the Check List lists "engine run-up", the amplified

© 1996 General Aviation Manufacturers Association

procedures would explain how to perform the run-up. Items essential or pertinent to the operation of the airplane not included in the Check List may also be included in this Section following the information on items in the Check List.

4.9 Normal Procedures

Except when inapplicable or inappropriate to the particular airplane model, Handbooks shall contain the recommended normal procedures for the following phases of flight, in the order shown.

(a) Preflight Inspection
(b) Before Engine Starting
(c) Use of External Power
(d) Engine Starting
(e) Before Taxiing
(f) Taxiing
(g) Before Takeoff
(h) Takeoff
- Normal
- Short Field*
- Soft Field*

(i) Climb
(j) Cruise
(k) Descent
(l) Before Landing
(m) Landing
- Normal
- Short Field*
- Soft Field*
- Balked

(n) After Landing
(o) Shutdown
(p) Postflight ELT

* Where such operations are approved

4.11 Environmental Systems

Include information necessary for safe operation of:

(a) Oxygen Systems (include capacity and duration)
(b) Pressurization System
(c) Heating & Ventilating Systems
(d) Air Conditioning Systems

4.13 Other Normal Procedures

Other procedures essential or pertinent to the operation of the airplane may be included in the Handbook. Generally, this will include information based on the standard or typical airplane and its systems and equipment. Information on specific optional systems or equipment may be included in this Section or in Section 9, Supplements. This Section may also include normal procedures for features peculiar to a particular airplane design or to particular handling characteristics. For example, spin recovery techniques may be included in this Section of an acrobatic category airplane Handbook.

4.15 Noise Characteristics

In addition to information required by Part 36 of the Federal Aviation Regulations, the Handbook producer shall provide strongly worded advice to be used by the operator to minimize the noise impact of the airplane during operation at, or in the vicinity of, airports.

4.17 Procedures for Practice Demonstration of V_{MCA}

For multi-engine airplanes, procedures shall be provided for practice demonstrations of V_{MCA}. The procedures shall be based on the use of V_{SSE}, *Intentional One Engine Inoperative Speed.*

The procedure shall specify that intentionally rendering one engine inoperative for the purpose of demonstrating, or training in, the recognition of V_{MCA} will be done by starting at or above V_{SSE}, then gradually reducing the speed (at approximately one knot per second) until either V_{MCA} or stall warning, whichever occurs first, is obtained.

Some types of airplanes (e. g., turbopropeller powered) may have V_{MCA} determined with automatic propeller pitch control devices that may have substantially more drag from an engine operating at reduced power, to simulate an engine failure, than with an inoperative engine. In such cases (where V_{SSE} is established at a speed to accommodate simulated engine failure by power reduction) the procedures shall include an explanation of the difference between simulated and actual power loss.

There should be a note that V_{SSE} is used only in training and is not a limiting speed.

4.19 Fuel Conservation

(a) Recommended fuel conservation procedures, appropriate to all phases of ground and flight operations, considering engine cooling, performance, and economy, shall be integrated into this Section (and, as appropriate, in Section 5, Performance). The main objective is to show how to maximize ground (nautical) miles per gallon (pound) by careful flight planning and

© 1996 General Aviation Manufacturers Association

attention to good operating procedures. The information may be expressed in discussing examples, graphs, tables or other means, or any combination thereof. In addition, general information and tips on fuel conservation may be included in Section 10 of the Handbook (if incorporated).

(b) The information shall include a discussion of the effects of variables (such as leaning and power settings, wind components, air temperature, cruise speeds, altitudes and weight) on fuel consumption. The significant tradeoffs to be considered in order to obtain the best fuel economy must be explained.

(c) The recommended fuel conservation procedures shall contain a caution, if applicable, that the power settings recommended by the manufacturer must be used during the break-in period of new and newly overhauled engines. The use of economy power settings during this period may be detrimental to the engine life.

© 1996 General Aviation Manufacturers Association

SECTION 5

PERFORMANCE

TABLE OF CONTENTS

Paragraph		Page
5.1	General	5-1
5.3	Fuel Conservation Information	5-1
5.5	Identification of Graphs & Tables	5-1
5.7	Limitations	5-1
5.9	Format Options	5-1
5.11	Readability of Graphs	5-1
5.13	Readability of Tables	5-1
5.15	Associated Conditions	5-1
5.17	Technique	5-2
5.19	Examples	5-2
5.21	Location of Examples, Associated Conditions and Technique	5-2
5.23	Weight	5-2
5.25	Airspeeds	5-2
5.27	Distances	5-2
5.29	Pressure Altitude & Air Temperature	5-2
5.31	Wind Velocities	5-2
5.33	Fuel Density	5-2
5.35	Performance Formats & Rules	5-2
5.37	Minimum Performance Presentations for Single Engine Aircraft	5-2
5.41	Minimum Performance Presentations for Multi-Engine Aircraft	5-4
5.42	Performances Presentations in Icing Conditions	5-6
	List of Figures	5-7

SECTION 5

PERFORMANCE

5.1 General

(a) This Section of the Pilot's Operating Handbook shall contain all performance information required by the Federal Aviation Regulations (or other applicable regulations) and this Specification. Additional performance and related information may be provided to enhance the pilot's operation of the airplane. The basis for such information may be stated (e . g., calculations, tests, analysis based on similar designs, etc.)

(b) The subject matter, including optional information, of this Section of the Handbook shall conform to the following general order of presentation unless a different order is more suitable for a particular airplane:

(1) Introduction, general information, and sample flight planning calculations.
(2) Takeoff.
(3) Climb.
(4) Cruise.
(5) Descent.
(6) Landing.

(c) Paragraphs 5.37 and 5.41 set forth the detailed, minimum subject matter and typical order of presentation within each phase of operation (or subject) listed in subparagraph (b) of this paragraph. Additional information provided by the manufacturer should be appropriately integrated into the order shown in paragraphs 5.37 or 5.41. Figures 5-29 and 5-30 are examples of orders of presentation in which optional items have been incorporated.

5.3 Fuel Conservation Information

Recommended Fuel Conservation Information shall be integrated into this Section to show the pilot how to minimize fuel usage during operation of the airplane.

5.5 Identification of Graphs or Tables

For standardization and user convenience, the titles in the "LIST OF FIGURES" on page 5-7 should be used to identify the appropriate items of airplane performance. Where two or more graphs or tables, which are similar in appearance, are used to cover the variation of items, such as alternative takeoff wing flap settings, the title information should be amplified as required to insure immediate recognition of the particular case.

5.7 Limitations

Limitations contained in this Section shall be clearly noted and cross-referenced to the appropriate paragraph in Section 2 of the Handbook.

5.9 Format Options

Airplane performance data shall be presented in either graphical or tabular formats.

5.11 Readability of Graphs

For graphical data presentations, the incremental value of the smallest graduation or pair of reticle lines should be the product of 1, 2, or 5, multiplied by an integral power of 10.

5.13 Readability of Tables

For tabular data presentations, independent variables shall be chosen so that linear interpolation of the data will provide a reasonable approximation of the function value to be extracted.

When other than simple interpolations in tables are involved, such as three way interpolations, explanations and examples of interpolation shall be included or a procedure for selecting conservative approximations may be given. This may be done in the Sample Flight Planning Section or on the specific table.

5.15 Associated Conditions

Each item of Airplane Performance shall include a statement of significant conditions associated with the data. As a minimum, the following information shall be provided as applicable.

(a) Power Setting and Propeller Condition
Note: Whenever a Maximum Normal Operating Power (MNOP) is included as a limitation, it may not be shown to be exceeded on any chart except those concerning takeoff, emergency, or abnormal procedures.
(b) Wing Flaps
(c) Cowl Flap Setting
(d) Landing Gear Position

© 1996 General Aviation Manufacturers Association

(e) Environmental System Operation
(f) Ice Protection System Operation
(g) Runway Precipitation, Slope and Surface Type
(h) Leaning Instructions

5.17 Technique
The technique or procedure necessary to duplicate the performance presented shall be included for those items of performance where the attainment of the predicted airplane performance requires a special sequence of actions.

5.19 Examples
Each graphical or tabular data presentation shall include one or more examples of the proper use of the data presentation unless its use is sufficiently simple that misuse or misunderstanding is improbable.
The examples shall:
(a) Illustrate the most general use of the presentation, avoiding special cases involving standard temperatures, reference weights, zero wind velocities, exact values of table entries or other occurrences not typical of actual situations.
(b) Present assumed example data in the order in which it must be used in the graph or table.
(c) Illustrate upon the face of the presentation graph or table, the successive entry of each assumed variable and the extraction of the end result.
(d) Demonstrate any necessary subsidiary computations which must be performed upon the result extracted from the presentation.
(e) Use assumed conditions, where applicable, the same as those used in the introduction to flight planning.

5.21 Location of Examples, Associated Conditions and Technique
Where possible, examples, associated conditions and technique should be presented on the same page as the chart. If space is not sufficient to include the necessary information, then the page facing the chart should be used.

5.23 Weight
Single engine airplanes require, as a minimum, data presented at the maximum weight. Data for multi-engine airplanes should be presented for a range of specified weights.

5.25 Airspeeds
Airspeed values shall be expressed in knots.

5.27 Distances
All range distances shall be expressed in nautical miles.

5.29 Pressure Altitude and Air Temperature
Only pressure altitude shall be used in specifying airplane performance where altitude is involved. No reference shall be made to density altitude. All airplane performance making use of air temperature shall be presented in terms of degrees Celsius only, or in terms of both Celsius and, Fahrenheit simultaneously. If Celsius only is used, a conversion chart between Celsius and Fahrenheit will be provided.

5.31 Wind Velocities
The effective wind components along the runway shall be taken as 50% of headwind components and 150% of tailwind components in all takeoff, landing, accelerate-stop, accelerate-go and other runway performance.

5.33 Fuel Density
For the purposes of range computations and related weight statements, the density of aviation gasoline shall be taken as 6.0 LB/U.S. Gal. and for aviation kerosene as 6.7 LB/U.S. Gal.

5.35 Performance Formats and Rules
The formats of performance presentations and related parameters and rules shall follow the examples in this Specification. If the format parameter or rule is inappropriate to the type of airplane, equivalents likely to achieve the same objective may be used. The notes on example graphs and tables in this Section are for guidance only.

5.37 Minimum Performance Presentations for Single Engine Airplanes
(a) *Introduction to Performance and Flight Planning*
An actual trip, employing realistic or actual conditions, shall be planned utilizing as much of the performance section as possible. Include sample calculations and any information which will facilitate the proper use and application of performance information including an introduction to tabulated performance. (Figure 5-1)
(b) *Airspeed Calibration*

© 1996 General Aviation Manufacturers Association

Data shall be presented as Calibrated Airspeed (CAS) versus Indicated Airspeed (IAS) assuming zero instrument error. The presentation for the normal airspeed system should include data for all flap configurations for which performance is quoted. The presentation for the alternate airspeed system, if applicable, should include data for cruise and landing flap configurations. All calibration data should cover the appropriate speed operating range. (Figure 5-2 or 5-3)

(c) *Altimeter Corrections*
Data shall be presented as altimeter correction versus indicated airspeed at the option of the manufacturer. The presentation should be included for those configurations and airspeed systems for which airspeed calibration data are presented. As a minimum, data should be presented at 5000 feet. A second table should be added if tabular data are presented at more than one altitude. (Figure 5-4 or 5-5)

(d) *Stall Speeds*
Data shall be presented as indicated airspeed and calibrated airspeed versus flap configurations (any flap position for which performance has been quoted) and angle of bank at maximum weight with throttle closed. Altitude loss of more than 100 feet and pitch below the horizon of more than thirty degrees during recovery from stalls should be added if applicable. (Figure 5-6 or 5-7)

(e) *Takeoff Distance*
Data shall be presented as distance versus outside air temperature, altitude and wind. Both ground roll and total distance over a 50 foot obstacle shall be included. The speeds required to attain these distances shall be scheduled in IAS. Unless a higher margin is required by the certification basis, for airplanes certificated after January 1, 1985, regardless of certification basis, the speed(s) at the 50 foot obstacle may not be less than 20% above the power-off stall speed for the same airplane configuration. The speed(s) for which ground roll distances were determined should be higher than the power-off stall speed for the same configuration. The chart should incorporate the limits of temperature and altitude where performance in the takeoff configuration has become marginal. The limiting criteria should involve the capability to climb in the takeoff configuration, free of ground effect, at 50 fpm for retractable gear and 150 fpm for fixed gear airplanes. This limiting rate-of-climb value shall be identified clearly on the chart along with the power and configuration conditions. (Figure 5-9 or 5-10)

(f) *Rate-of-Climb*
Data shall be presented as rate-of-climb versus outside air temperature and altitude at maximum weight and maximum power approved for climb. Climb speed(s) should be either the best rate-of-climb speed or an average best rate-of climb speed and scheduled in IAS. (Figure 5-13 or 5-14)

(g) *Time, Fuel and Distance to Climb*
Data shall be presented as time, fuel and distance to climb from sea level versus altitude on a standard day (ISA). The climb speeds should be scheduled in IAS on the chart and preferably selected so that they will provide optimum range performance. The power setting(s) used shall be no more than the maximum nonemergency climb rating. The associated conditions of power and fuel flow should be specified. (Figure 5-17 or 5-18)

(h) *Cruise*
Data shall be presented as engine power settings, (manifold pressure, engine or propeller speed, fuel flow or whatever parameters are required to establish power) and true airspeed versus altitude and temperature. The format of the cruise performance presentation is at the discretion of the airplane manufacturer, but should consider the following:

1. The format should not rely on devices such as a power computer.
2. The format should be simple to use for both preflight planning and inflight establishment of power.
3. The proper use of the data should be explained.

(i) Range Profiles
Data should be presented as range of airplane versus altitude for various power settings and at least a full fuel loading. Range values should include an allowance for fuel to start, taxi, takeoff, climb and reserve. The following guidelines should be adhered to:

1. For start, taxi and takeoff, allow 5 minutes of fuel flow at takeoff power.
2. For climb, assume a sea level takeoff and use the data presented on the time, fuel and distance to climb chart.

© 1996 General Aviation Manufacturers Association

3. For all fuel loadings, the initial airplane weight should be the maximum allowable.
4. Reserve shall be computed as 45 minutes at the cruise power to be used for the flight. The explanation information presented with the chart should explain how the reserve was computed.
5. Range should be computed at standard day (ISA) temperatures.
6. Range values should be included for at least the maximum and minimum power settings for which information has been presented in the Handbook.
7. Range value shall not include parameters or variables that have not been presented in the Handbook.

The sample graph is presented for only one fuel loading. Additional fuel loadings may be presented either as a secondary scale on the same chart or as an additional graph. (Figure 5-21)

(j) *Endurance Profile*

Data shall be presented as endurance time of airplane versus altitude for various power settings and at least a full fuel loading. Endurance should be calculated applying the same guidelines as for range profiles and for the same conditions. (Figure 5-22)

(k) *Landing Distance*

Data shall be presented as landing distance versus outside air temperature altitude and wind. Both ground roll and the total distance over a 50 foot obstacle shall be included. The speed(s) at the 50 foot height point required to obtain the total distance shall be included. (Figure 5-27 or 5-28)

5.41 Minimum Performance Presentations for Multi-Engine Airplanes

(a) *Introduction to Performance and Flight Planning*

An actual trip, employing realistic or actual conditions, shall be planned utilizing as much of the performance section as possible. Include sample calculations and any information which will facilitate the proper use and application of performance information including introduction to tabulated performance. (Figure 5-1)

(b) *Airspeed Calibration*

Data shall be presented as Calibrated Airspeed (CAS) versus Indicated Airspeed (IAS) assuming zero instrument error. The presentation for the normal airspeed system should include data for all flap configurations for which performance is quoted. The presentation for the alternate airspeed system, if applicable, should include data for cruise and landing flap configurations. All calibration data should cover the appropriate speed operating range. (Figure 5-2 and 5-3)

(c) *Altimeter Corrections*

Data shall be presented as altimeter correction versus indicated airspeed and altitude at the option of the manufacturer. The presentation should be included for those configurations and airspeed systems for which airspeed calibration data are presented. If tabular data are presented repeat the table for additional altitudes. (Figure 5-5 or 5-5)

(d) *Stall Speeds*

Data shall be presented as indicated and calibrated airspeed versus flap configurations (any flap position for which performance has been quoted), angle of bank and weight with throttles closed. If tabular presentation is used, repeat the table of additional weights. Altitude loss of more than 100 feet and pitch below the horizon of more than 30 degrees during recovery from stalls should be added if applicable. (Figure 5-6 or 5-7)

(e) *Maximum Takeoff Weight (If Applicable)*

Data shall be presented as maximum takeoff weight versus temperature and altitude. The chart shall be clearly identified as a limitation in accordance with Paragraph 5.7. (Figure 5-8)

(f) *All Engines Operating Take off Distance*

Data shall be presented as distance versus outside air temperature, altitude, weight, and wind. Both ground roll and total distance over a 50 foot obstacle shall be included. The speeds required to attain these distances shall be scheduled in IAS. The speed(s) at the 50 foot obstacle height may not be less than 20% above the power-off stall speed(s) for the same airplane configuration or 10% above V_{MCA}, whichever is higher. The speed(s) at the end of the ground roll distances(s) may not be less than 5% above the power-off stall speed(s) for the same airplane configuration or 5% above V_{MCA}, whichever is higher. The chart shall indicate the extremes of temperature and altitude where all engine performance in the takeoff configuration becomes marginal. These extremes should

© 1996 General Aviation Manufacturers Association

involve the capability to climb in the takeoff configuration, free of ground effect, at 50 fpm for retractable gear airplanes and 150 fpm for fixed gear airplanes. This limiting rate-of-climb value shall be clearly identified on the chart, along with the power and configuration conditions. (Figure 5-9 or 5-10)

(g) *Accelerate-Stop Distance*
Data shall be presented as distance versus outside air temperature, altitude, weight and wind. Distances should include acceleration, deceleration and a time delay at engine failure speed equivalent to 3 seconds at the engine failure speed. Engine failure speed(s) shall be the same as the lift-off speed(s) assumed on the All Engines Operating Takeoff Distance chart except lower values may be used when a corresponding "accelerate-go" chart has been provided. (Figure 5-11 or 5-12)

(h) *Rate-of-Climb*
Data shall be presented as rate-of-climb versus outside air temperature, altitude and weight at the maximum power approved or as specified by the appropriate FAA requirements. Separate charts shall be included for the following:

1. Rate-of-Climb-all engines operating with flaps set to the takeoff position and landing gear retracted.
2. Rate-of-Climb-all engines operating with flaps set to the enroute position and landing gear retracted (If applicable)
3. Rate-of-Climb-one engine inoperative with flaps set to the enroute position and landing gear retracted.
4. Rate-of-Climb-Balked Landing.
   The climb speeds appropriate to each configuration shall be scheduled in IAS. (Figure 5-13 or 5-14)

(i) *Service Ceiling-One Engine Inoperative*
Data shall be presented as service ceiling and outside air temperature versus weight. Service ceiling shall be the pressure altitude where an airplane has the capability of climbing 50 ft/min with one engine propeller feathered. (Figure 5-15 or 5-16)

(j) *Time, Fuel and Distance to Climb*
Data shall be presented as time, fuel and distance to climb from sea level versus outside air temperature, altitude and weight. The climb speed(s) should be scheduled in IAS on the chart and preferably selected so that they will provide optimum range performance. The power setting(s) should not exceed the maximum nonemergency climb power rating and all associated conditions should be specified. (Figure 5-17 or 5-18)

(k) *Cruise*
Data shall be presented as engine power setting (manifold pressure, engine or propeller speed, fuel flow or whatever parameters are required to establish power) and true airspeed versus altitude and temperature. The effect of weight should also be scheduled if it significantly affect cruise performance. The format of the cruise performance presentation is at the discretion of the airplane manufacturer, but should consider the following:

1. The format should not rely on devices such as a power computer.
2. The format should be simple to use for both preflight planning and inflight establishment of power.
3. The proper use of the data should be explained.

(l) *Range Profiles*
Data shall be presented as range of airplanes versus altitude for various power settings and at least a full fuel loading. Range values should include an allowance for fuel to start, taxi, takeoff, climb, descend and reserve. The following guidelines should be adhered to:

1. For start, taxi, and takeoff, allow 5 minutes of fuel flow at takeoff power.
2. For climb, assume a sea level takeoff and use the data presented on the time, fuel and distance to climb chart.
3. For descent, assume a descent from cruise altitude to sea level and use the data presented on the time, fuel and distance to descend chart.
4. For all fuel loadings, the initial airplane weight should be the maximum allowable.
5. Reserve shall be computed as 45 minutes at the cruise power to be used for the flight. The explanation information presented with the chart should explain how the reserve was computed.
6. Range should be computed at standard day (ISA) temperatures.
7. Range values should be included for at least the maximum and minimum power

© 1996 General Aviation Manufacturers Association

settings for which information has been presented in the Handbook.

8. Range values shall not include parameters or variables that have not been presented in the Handbook.

   The sample graph is presented for only one fuel loading.

   Additional fuel loadings may be presented either as a secondary scale on the same chart or as an additional graph. (Figure 5-21)

(m) *Endurance Profile*

Data shall be presented as endurance time versus altitude for various power settings and at least a full fuel loading. Endurance should be calculated applying the same guidelines as for range profiles and for the same conditions. (Figure 5-22)

(n) *Holding Time*

Data shall be presented as holding time versus altitude and fuel required at a recommended power setting for holding. (Figure 5-23 or 5-24)

(o) *Time, Fuel & Distance to Descend*

Data shall be presented as time, fuel and distance to descend to sea level versus altitude. The conditions of speed and rate-of-descent should be selected by the airplane manufacturer and specified. The format is the same as the graph or table for time, fuel and distance to climb for single engine aircraft. (Figure 5-25 or 5-26)

(p) *Landing Distance*

Data shall be presented as landing distance versus outside air temperature altitude, weight and wind. Both ground roll and the total distance over a 50 foot obstacle shall be included. The speed(s) at the 50 foot height point required to obtain the total distance shall be scheduled. (Figure 5-27 or 5-28)

5.42 Performance Presentations in Icing Conditions

(a) *Introduction*

Appendix C of FAR Part 25 defines specific parameters for certification of aircraft for operations in continuous maximum and intermittent maximum icing conditions. Atmospheric conditions, including large supercooled water droplets, freezing rain or a mixture of conditions, may exceed the FAR parameters and the capabilities of the certified ice protection system. This information shall be presented along with information to aid recognition of icing conditions which may exceed the certified capabilities of the aircraft and its ice protection system.

(b) *Operations in Icing Conditions*

Data shall be presented by general statements of allowances necessary while operating in icing conditions or with residual ice on the airframe.

(1) Data providing loss in rate of climb (FPM), reduction in cruise speed (KIAS) and significant buffet and stall speed increase (KTS) for a selected ice accumulation and for residual ice remaining on the boots and unprotected areas of the airplane.

(2) Data providing airspeed recommendations for operating with selected accumulations of ice or residual ice shall be presented.

(3) Data providing airspeed recommendations and effects of boot operations prior to and during the landing approach.

(4) Recommendations for ATC holding operation in icing conditions for up to 45 minutes (or less if so demonstrated).

(5) Recommendations, if any, for engine operating parameter effects on the ice protection system or on performance of the engine in icing conditions.

(c) *Presentation Formats*

FAA Advisory Circular 23.1419-2, Certification of Part 23 Airplanes For Flight In Icing Conditions, contains recommendations for presentation of data and limitations. Reference to this Advisory Circular during preparation of the Pilot's Operating Handbook is encouraged.

© 1996 General Aviation Manufacturers Association

LIST OF FIGURES

Figure No.

Introduction to Tabulated Performance.................................5-1
Airspeed Calibration
Graph 5-2
Table 5-3
Altimeter Correction
Graph 5A
Table 5-5
Stall Speeds
Graph 5-6
Table 5-7
Maximum Takeoff Weight 5-8
Takeoff Distance
Graph 5-9
Table 5-10
Accelerate-Stop Distance
Graph 5-11
Table 5-12
Rate-of-Climb
Graph 5-13
Table 5-14
Single Engine Service Ceiling
Graph 5-15
Table 5-16
Time, Fuel & Distance to Climb
Single Engine Airplane - Graph....................................5-17
Single Engine Airplane - Table....................................5-18
Multi-Engine Airplane - Graph.....................................5-19
Multi-Engine Airplane - Table.....................................5-20
Fuel and Time Required..5-20A
Range Profile 5-21
Endurance Profile..5-22
Holding Time
Graph 5-23
Table 5-24
Time, Fuel & Distance to Descend
Graph 5-25
Table 5-26
Landing Distance
Graph 5-27
Table 5-28
Identification of Graphs or Tables -
Single Engine Airplane..5-29
Multi-Engine Airplane...5-30

© 1996 General Aviation Manufacturers Association

INTRODUCTION TO TABULATED PERFORMANCE:

Tabulations of performance are presented in increments of temperature, altitude and any other variables involved. Performance for a given set of conditions may be approximated as follows:

Takeoff, climb, and landing - Enter tables at the next higher increment of altitude, temperature, weight and at zero wind.

Cruise Enter tables at next lower increment of temperature, altitude and fuel loading; and the next higher increment of weight, if applicable.

To obtain exact performance values from tables, it is necessary to interpolate between the incremental values.

The following is an excerpt from the Table for Takeoff Distances:

WEIGHT LBS	TAKEOFF SPEED KNOTS ~ IAS		PRESS ALT FT	20°		30°	
	LIFT OFF	50 FT		GROUND ROLL	TOTAL TO CLEAR 50 FT OBS	GROUND ROLL	TOTAL TO CLEAR 50 FT OBS
11,800	101	118	2000	2410	3850	2720	4320
			4000	2840	4600	3230	5020
11,000	98	115	2000	2170	3450	2415	3800
			4000	2580	4015	2860	4450

NOTE: DECREASE DISTANCE 4% FOR EACH 5 KNOTS HEADWIND

EXAMPLE

GIVEN: WEIGHT 11,275 LBS.

OUTSIDE AIR TEMPERATURE 25°C

PRESSURE ALTITUDE 3966 FT

HEADWIND 9.5 KNOTS

FIND: TAKEOFF SPEEDS AT LIFT-OFF

50 FEET

GROUND ROLL

TOTAL DISTANCE TO CLEAR 50 FT OBSTACLE

APPROXIMATION METHOD:

Read values at 11,800 lbs., 30°6 and 4,000 feet:

Takeoff Speeds

Lift-off	101 KIAS
50 feet	118 KIAS
Ground Roll	3230 FEET
Total to Clear 50' Obstacle	5020 FEET

INTERPOLATION METHOD:

The example weight is 34% of the difference between 11,000 and 11,800 pounds.

The example pressure altitude is 98% of the difference between 2000 and 4000 feet.

The example temperature is 50% of the difference between 20° and 30°6.

Summary of Interpolated Values:

Takeoff Speeds

Lift-off	99 KIAS
50 feet	116 KIAS
Ground Roll	2818 FEET
Total to Clear 50' Obstacle	4416 FEET

Correction for Head Wind:

For a 9.5 Knot Headwind, decrease distances by 7.6%.

Ground Roll 2818-(7,6%) (2818) = 2604 feet

Total to Clear 441~(7.6%) (4416) = 4080 feet

Figure 5-1

© 1996 General Aviation Manufacturers Association

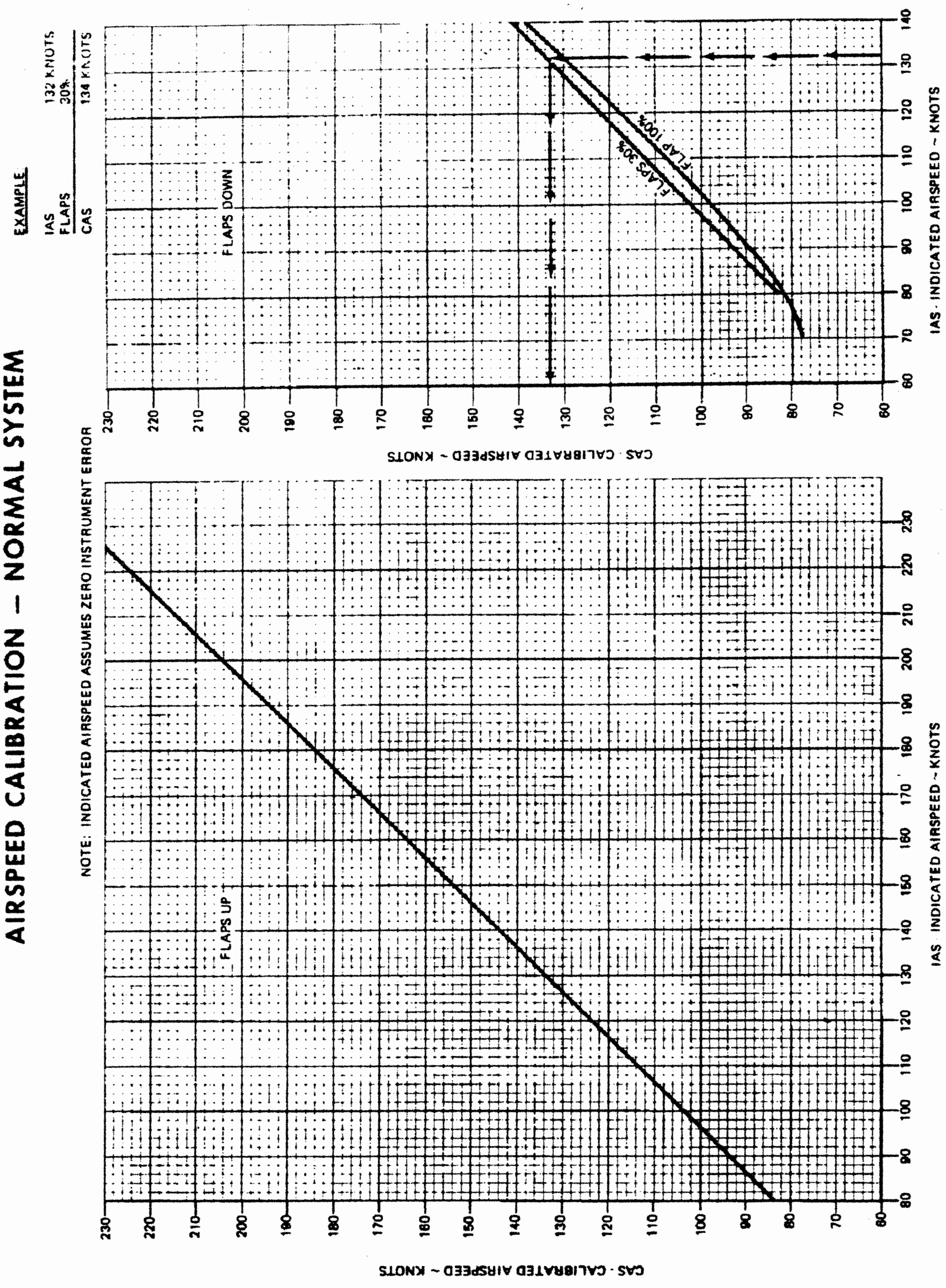


Figure 5-2

© 1996 General Aviation Manufacturers Association

AIRSPEED CALIBRATION – NORMAL SYSTEM

EXAMPLE:

FLAPS FULL
INDICATED AIR SPEED 110 KIAS

CALIBRATED AIR SPEED 109 KCAS

NOTE:

INDICATED AIRSPEED ASSUMES ZERO INSTRUMENT ERROR.

FLAPS UP	KIAS	60	100	120	140	160	180	200
	KCAS	87	101	118	137	166	176	196
FLAPS 1/3	KIAS	70	80	90	100	120	140	160
	KCAS	79	85	92	100	117	135	155
FLAPS FULL	KIAS	65	75	85	95	105	115	125
	KCAS	71	79	86	95	104	113	122

KIAS = INDICATED AIRSPEED IN KNOTS
KCAS = CALIBRATED AIRSPEED IN KNOTS

Figure 5-3

© 1996 General Aviation Manufacturers Association
Issued: February 15, 1975
Revised: October 18, 1996

ALTIMETER CORRECTION – NORMAL SYSTEM

NOTE: INDICATED AIRSPEED AND INDICATED ALTITUDE ASSUME ZERO INSTRUMENT ERROR

EXAMPLE:

IAS	132 KNOTS
FLAPS	30%
PRESSURE ALTITUDE	4000 FEET
ALTIMETER CORRECTION	+ 20 FEET (ADD TO INDICATED ALT)

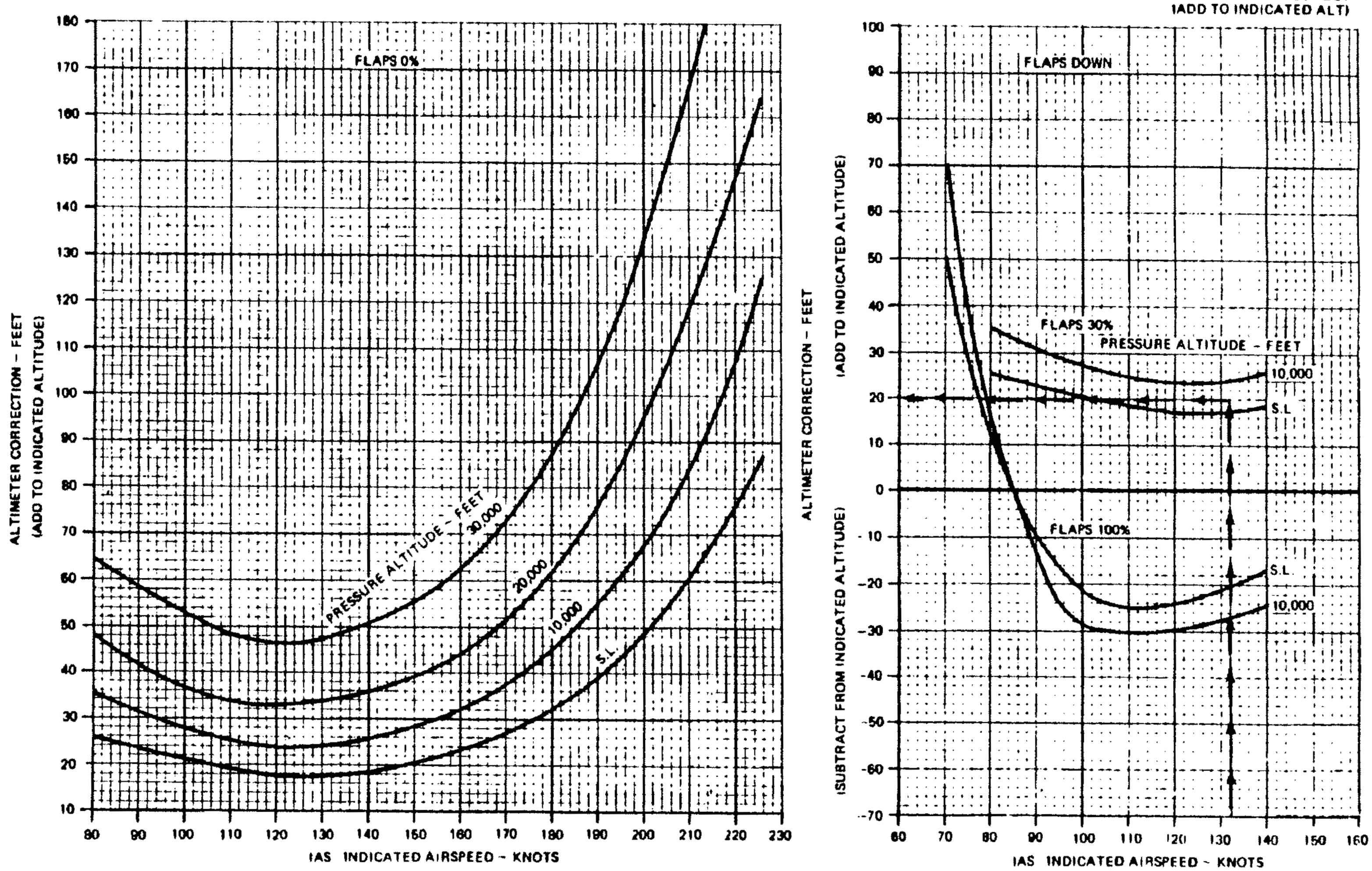


Figure 5-4

© 1996 General Aviation Manufacturers Association

ALTIMETER CORRECTION – NORMAL SYSTEM

EXAMPLE:

FLAPS	FULL	
INDICATED AIR SPEED	95	KIAS
CORRECTION TO BE ADDED	-30	FT

NOTE:

1. ADD CORRECTION TO INDICATED ALTIMETER READING.
2. IAS AND INDICATED ALTITUDE ASSUME ZERO INSTRUMENT ERROR.

CONDITION	CORRECTION TO BE ADDED ∿ FEET					
	KNOTS IAS					
	80	100	120	140	160	180
FLAPS UP	-10	-20	-40	-60	-90	-115
FLAPS 1/3	-10	-35	-60	-80	-110	---
FLAPS FULL	-16	-35	-60	—	—	---

Figure 5-5

© 1996 General Aviation Manufacturers Association
Issued: February 15, 1975
Revised: October 18, 1996

STALL SPEEDS

POWER IDLE

NOTES:
1. MAXIMUM ALTITUDE LOSS DURING STALL RECOVERY IS APPROXIMATELY 800 FEET
2. MAXIMUM NOSE DOWN PITCH ATTITUDE AND ALTITUDE LOSS DURING RECOVERY FROM SINGLE ENGINE STALLS PER FAR 23.205 ARE APPROXIMATELY 10° AND 2000 FEET, RESPECTIVELY
3. LANDING GEAR POSITION HAS NO EFFECT ON STALL SPEED.

EXAMPLE:

WEIGHT	10,500 LBS
FLAPS	100%
ANGLE OF BANK	25°
STALL SPEED	77 KNOTS IAS 69 KNOTS CAS

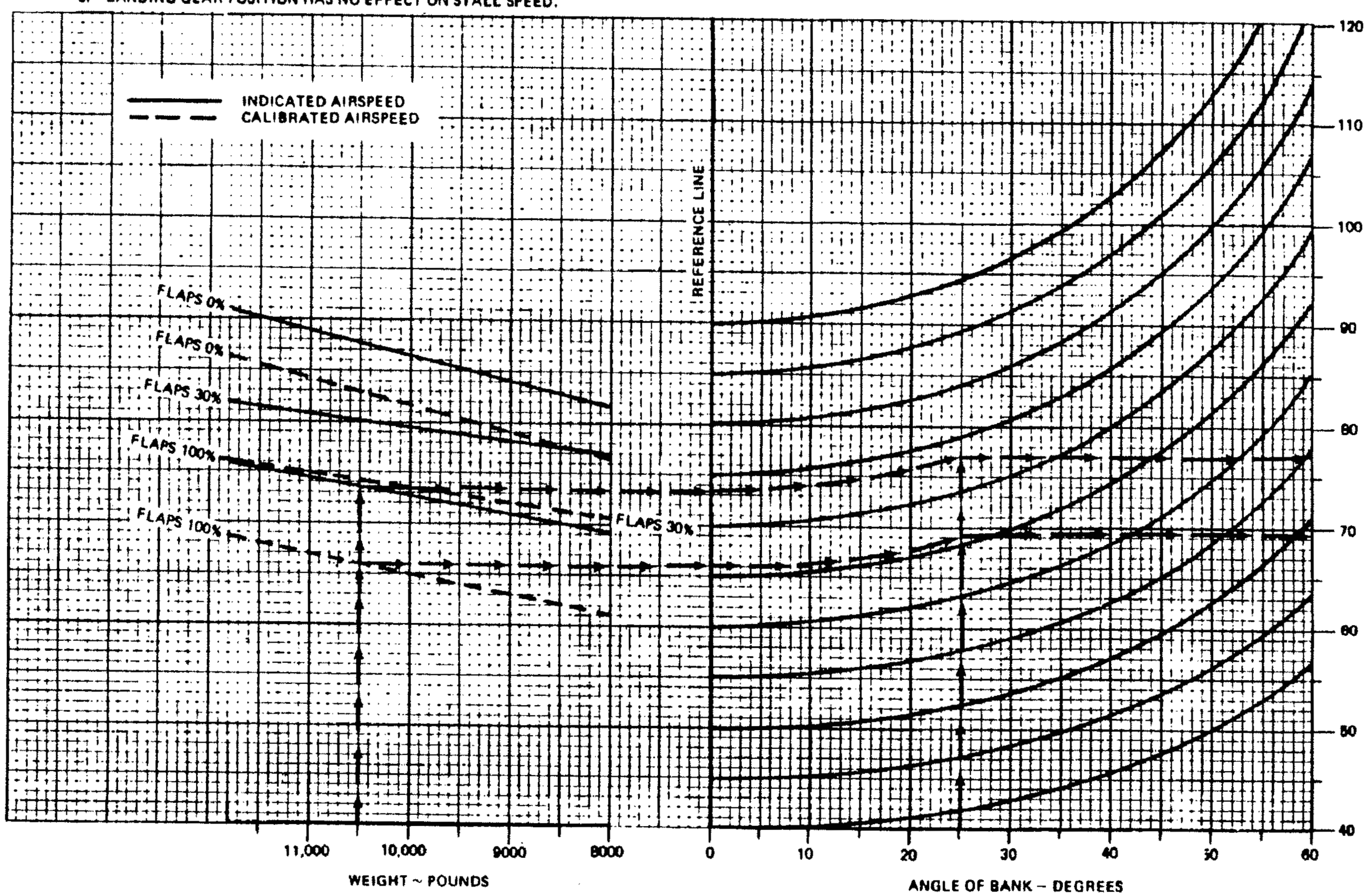


Figure 5-6

Figure 5-6

© 1996 General Aviation Manufacturers Association

STALL SPEEDS

ASSOCIATED CONDITIONS:

POWER	IDLE
LANDING GEAR	UP OR DOWN

EXAMPLE:

WEIGHT	4600 LBS.
LANDING GEAR	DOWN
FLAPS	100%
ANGLE OF BANK	15°
STALL SPEED	58 KIAS 64 KCAS

NOTES:

1. MAXIMUM ALTITUDE LOSS DURING STALL RECOVERY IS APPROXIMATELY 800 FEET.

2. MAXIMUM NOSE DOWN PITCH ATTITUDE AND ALTITUDE LOSS DURING RECOVERY FROM SINGLE ENGINE STALLS ARE APPROXIMATELY 10° AND 2000 FEET, RESPECTIVELY

3. LANDING GEAR POSITION HAS NO EFFECT ON STALL SPEEDS.

WEIGHT LBS.	CONDITION	STALL SPEEDS ~ KNOTS							
		ANGLE OF BANK							
		0°		30°		45°		60°	
		IAS	CAS	IAS	CAS	IAS	CAS	IAS	CAS
4600	FLAPS UP	60	69	64	74	71	62	85	98
	FLAPS 1/3	57	68	61	71	68	78	81	93
	FLAPS FULL	56	62	60	66	67	74	79	88

Figure 5-7

© 1996 General Aviation Manufacturers Association

MAXIMUM TAKEOFF WEIGHT
OPERATING LIMITATION

EXAMPLE:

PRESSURE ALTITUDE	3200 FEET
OAT	30°C
MAXIMUM TAKEOFF WEIGHT	11,000 LBS

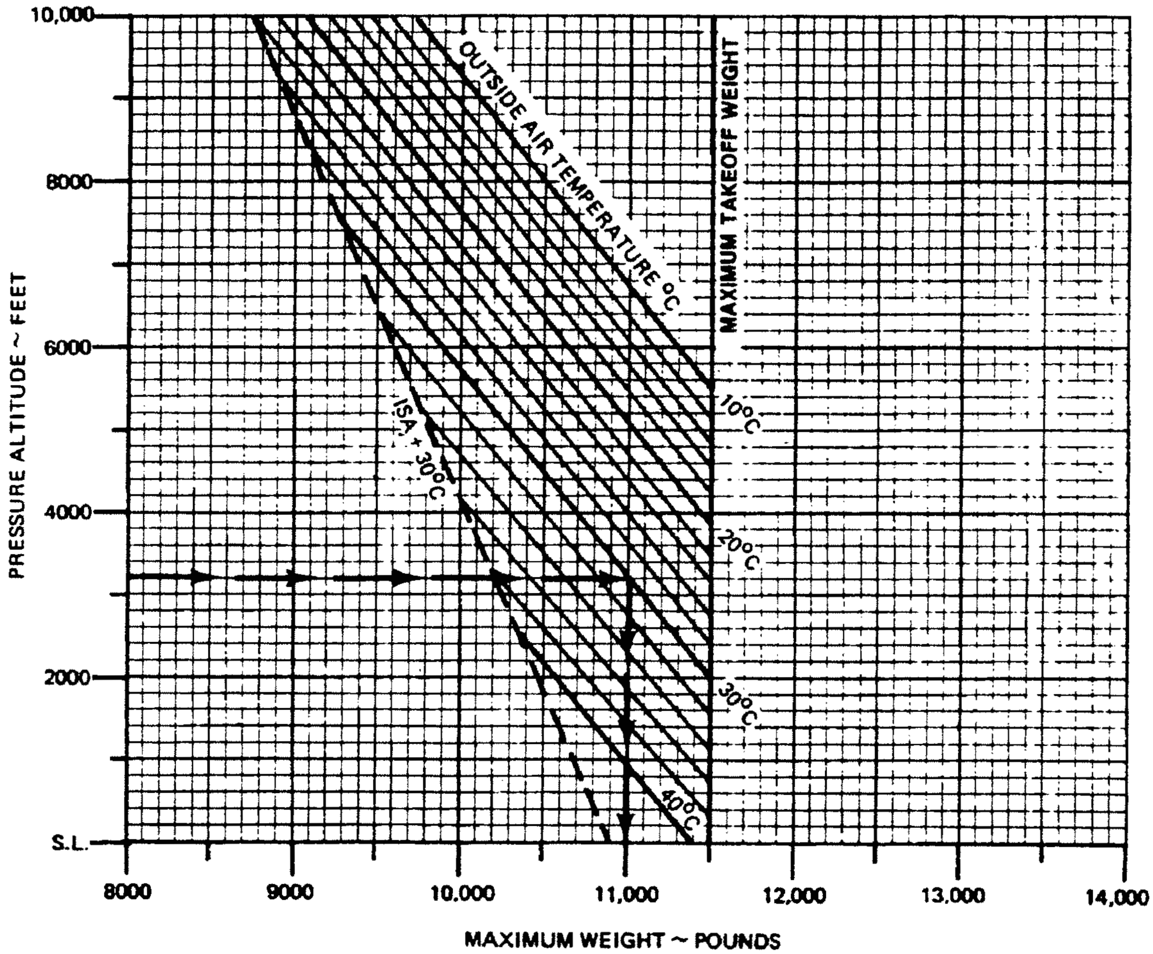


Figure 5-8

© 1996 General Aviation Manufacturers Association

TAKEOFF DISTANCE — 0% FLAPS

ASSOCIATED CONDITIONS:

POWER	TAKEOFF POWER SET BEFORE BRAKE RELEASE
FLAPS	0%
LANDING GEAR	RETRACT AFTER LIFT-OFF
RUNWAY	PAVED, LEVEL, DRY SURFACE

WEIGHT POUNDS	TAKEOFF SPEED KNOTS – IAS	
	LIFT-OFF	50 FT
11,800	101	118
11,000	98	115
10,000	96	113
9000	93	109
8000	93	106

EXAMPLES:

OAT	25°C
PRESSURE ALTITUDE	3966 FEET
TAKEOFF WEIGHT	11,275 LBS
HEADWIND COMPONENT	9.5 KNOTS
GROUND ROLL	2620 FEET
TOTAL DISTANCE OVER A 50 FOOT OBSTACLE	4200 FEET
TAKEOFF SPEED AT LIFT-OFF	99 KIAS
AT 50 FEET	116 KNOTS IAS

NOTES: 1. CLIMB PERFORMANCE AFTER LIFT-OFF IS LESS THAN 50 FT/MIN IF TAKEOFF WEIGHT IS IN THE SHADED AREA. RATE-OF-CLIMB IS BASED ON ALL ENGINES OPERATING AT TAKEOFF POWER, LANDING GEAR DOWN AT TAKEOFF SPEED.
2. IF TAKEOFF POWER SET WITHOUT BRAKES APPLIED, THEN DISTANCES APPLY FROM POINT WHERE FULL POWER IS ATTAINED.

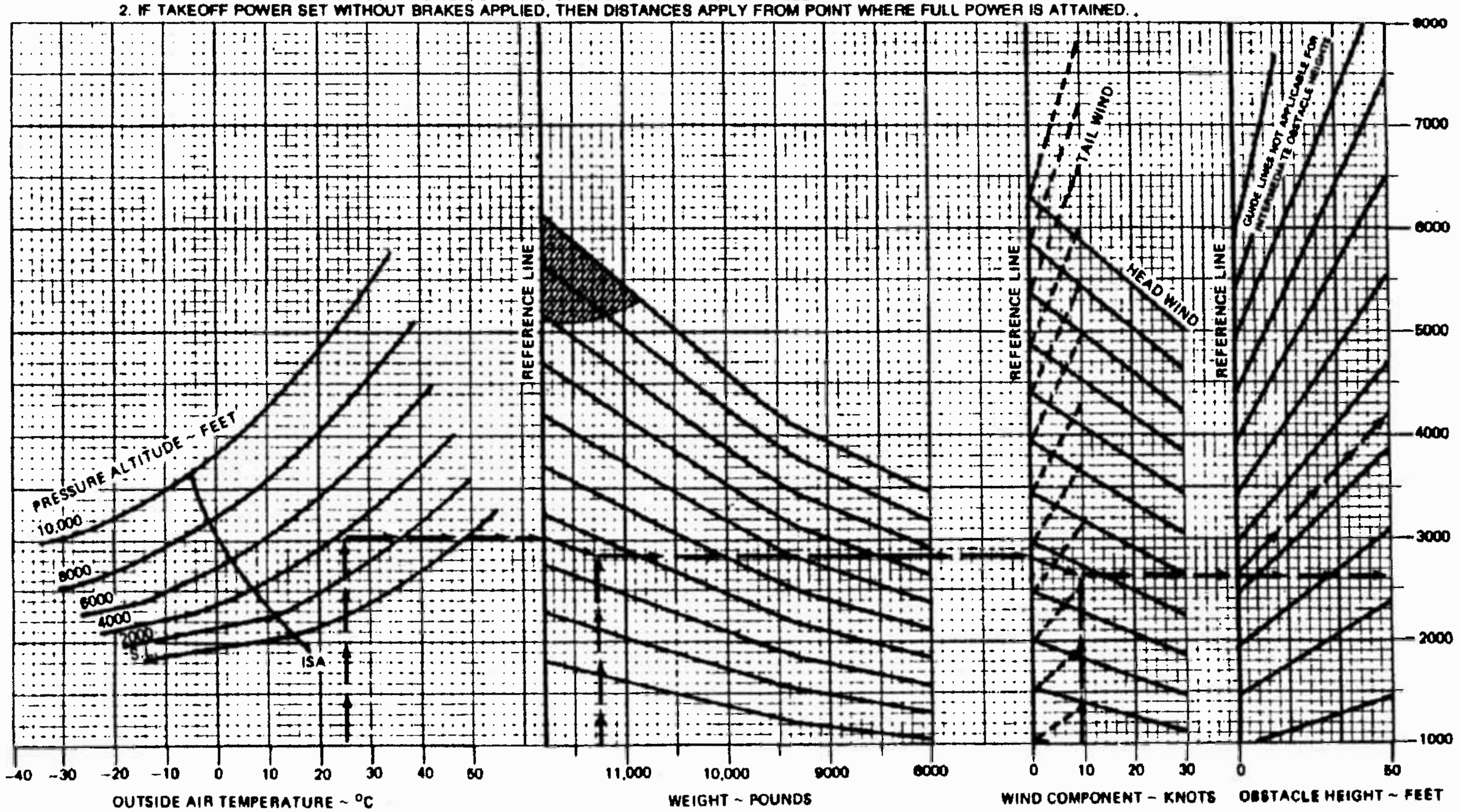


Figure 5-9

© 1996 General Aviation Manufacturers Association

TAKEOFF DISTANCE

ASSOCIATED CONDITIONS:

POWER	TAKEOFF POWER SET BEFORE BRAKE RELEASE
FLAPS	0%
LANDING GEAR	RETRACTED AFTER LIFT-OFF
RUNWAY	PAVED, LEVEL, DRY SURFACE

EXAMPLE:

WEIGHT	11,275 LBS
OUTSIDE AIR TEMPERATURE	25°C
PRESSURE ALTITUDE	3966 FT
HEADWIND COMPONENT	9.5 KTS
GROUND ROLL	2604 FT
TOTAL TO CLEAR 50 FT. OBS.	4080 FT
TAKEOFF SPEED AT LIFT-OFF	99 KIAS
50 FEET	116 KIAS

NOTES:

1. DECREASE DISTANCES 4% FOR EACH 5 KNOTS HEADWIND. FOR OPERATION WITH TAILWINDS UP TO 10 KNOTS, INCREASE DISTANCES BY 6% FOR EACH 2.5 KNOTS.
2. WHERE DISTANCE VALUE HAS BEEN DELETED, CLIMB PERFORMANCE AFTER LIFT-OFF IS LESS THAN ___ FT/MIN. RATE-OF-CLIMB IS BASED ON ALL ENGINES OPERATING AT TAKEOFF POWER, GEAR DOWN AT TAKEOFF SPEED.
3. IF TAKEOFF POWER SET WITHOUT BRAKES APPLIED, THEN DISTANCE APPLY FROM POINT WHERE FULL POWER IS ATTAINED.

WEIGHT LBS	TAKEOFF SPEED KNOTS ∿ IAS		PRESS ALT FT	0°C		10°C		20°C		30°C		40°C	
	LIFT OFF	50 FT		GROUND ROLL	TOTAL TO CLEAR 50 FT OBS	GROUND ROLL	TOTAL TO CLEAR 50 FT OBS	GROUND ROLL	TOTAL TO CLEAR 50 FT OBS	GROUND ROLL	TOTAL TO CLEAR 50 FT OBS	GROUND ROLL	TOTAL TO CLEAR 50 FT OBS
11800	101	118	SL	1950	3075	2030	3225	2165	3420	2370	3700	2680	4215
			2000	2150	3400	2225	3550	2410	3850	2720	4320	3180	5015
			4000	2375	3700	2550	4140	2840	4600	3280	5020	3700	6000
			6000	2730	4300	3050	4875	3400	5560	3780	6200	4350	7250
			8000	3240	5125	3600	5775	4040	6100	4575	7760	....	....
			10000	3840	6200	4270	7040	4815	8000	....	....	....	....
11000	98	115	SL	1710	2725	1800	2850	1915	3030	2100	3310	2375	3700
			2000	1890	3030	2010	3210	2170	3450	2415	3800	2775	4400
			4000	2110	3315	2340	3650	2580	4015	2880	4450	3230	5250
			6000	2400	3740	2700	4260	3030	4830	3400	5470	3900	6300
			8000	2850	4600	3225	5020	3600	5670	4070	6740	....	....
			10000	3420	5540	3780	6140	4265	7150	....	....	....	....
10000	95	113	SL	1450	2440	1540	2530	1650	2660	1810	2850	2040	3165
			2000	1650	2640	1760	2785	1900	2990	2090	3300	2375	3780
			4000	1825	2880	2010	3090	2225	3370	2465	3700	2785	4400
			6000	2075	3250	2315	3520	2570	3920	2880	4400	3315	5355
			8000	2460	3875	2700	4300	2970	4790	3400	5560	....	....
			10000	2910	4650	3230	5200	3650	5850	....	....	....	....

Figue 5-10

© 1996 General Aviation Manufacturers Association

ACCELERATE — STOP DISTANCE — 0% FLAPS

ASSOCIATED CONDITIONS:

POWER
1. TAKEOFF POWER SET BEFORE BRAKE RELEASE
2. BOTH ENGINES IDLE AT ENGINE FAILURE SPEED AND REVERSE OPERATING ENGINE

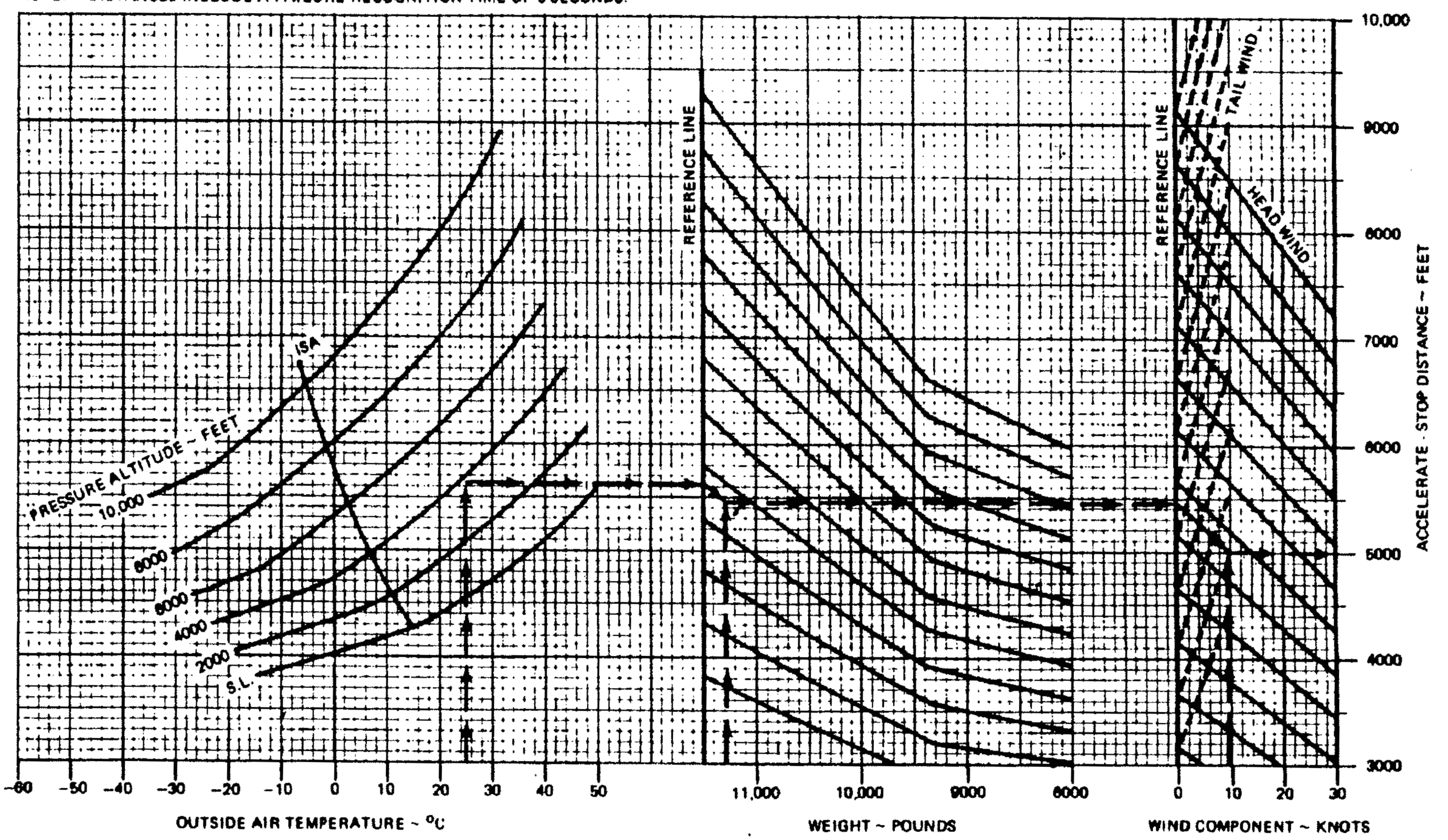
FLAPS 0%
BRAKING MAXIMUM
RUNWAY PAVED, LEVEL, DRY SURFACE

WEIGHT POUNDS	ENGINE FAILURE SPEED KNOTS IAS
11,500	99
11,000	96
10,000	91
9000	88
8000	88

EXAMPLE:

OAT	25°C
PRESSURE ALTITUDE	3966 FEET
WEIGHT	11,275 LBS
HEADWIND COMPONENT	9.5 KNOTS
ACCELERATE - STOP DISTANCE	5000 FEET
ENGINE FAILURE SPEED	98 KNOTS IAS

NOTE: DISTANCES INCLUDE A FAILURE RECOGNITION TIME OF 3 SECONDS.



Figue 5-11

© 1996 General Aviation Manufacturers Association
Issued: February 15, 1975
Revised: October 18, 1996

ACCELERATE - STOP ∿ 0% FLAPS

ASSOCIATED CONDITIONS:

POWER 1. TAKEOFF POWER SET BEFORE BRAKE RELEASE
2. BOTH ENGINES IDLE AT ENGINE FAILURE SPEED AND REVERSE OPERATING ENGINE.

FLAPS 0%
BRAKING MAXIMUM
RUNWAY PAVED, LEVEL, DRY SURFACE

EXAMPLE:

WEIGHT	11275 LBS
OUTSIDE AIR TEMPERATURE	25°C
PRESSURE ALTITUDE	3966 FT
HEADWIND COMPONENT	9.5 KTS

1. APPROXIMATION METHOD
   ACCELERATE-STOP DISTANCE 5870 FT
   ENGINE FAILURE SPEED 98 KIAS
2. INTERPOLATION METHOD
   ACCELERATE-STOP DISTANCE 5077 FT
   ENGINE FAILURE SPEED 98 KIAS

NOTE:

1. DECREASE DISTANCES 4% FOR EACH 5 KNOTS HEADWIND. FOR OPERATIONS WITH TAILWINDS UP TO 10 KNOTS, INCREASE DISTANCES BY 6% FOR EACH 2.5 KNOTS.
2. DISTANCES INCLUDE A FAILURE RECOGNITION TIME OF 3 SECONDS.

WEIGHT LBS.	ENGINE FAILURE SPEED	PRESSURE ALTITUDE FEET	0°C	10°C	20°C	30°C	40°C
			ACCELERATE - STOP DISTANCE ∿ FEET				
11500	99	SL	4025	4170	4370	4650	5100
		2000	4370	4570	4810	5150	5710
		4000	4725	5080	5450	5870	6500
		6000	5300	5740	6180	6670	7300
		8000	6020	6490	6975	7600	—
		10000	6800	7400	8010	8770	—
11000	96	SL	3800	3960	4160	4390	4770
		2000	4080	4310	4570	4890	5390
		4000	4400	4750	5120	5525	6060
		6000	5000	5350	5725	6150	6800
		8000	5625	6050	6520	7100	—
		10000	6375	6860	7480	—	—
10000	91	SL	3310	3460	3620	3840	4160
		2000	3560	3750	3950	4190	4660
		4000	3825	4130	4420	4750	5280
		6000	4325	4625	4950	5315	5840
		8000	4900	5235	5610	6075	—
		10000	5475	5900	6420	—	—

Figure 5-12

© 1996 General Aviation Manufacturers Association

RATE-OF-CLIMB — ONE ENGINE INOPERATIVE

ASSOCIATED CONDITIONS:

POWER	MAXIMUM CONTINUOUS
FLAPS	0%
LANDING GEAR	UP
BLEED AIR VALVES	CLOSED
INOPERATIVE PROPELLER	FEATHERED

WEIGHT POUNDS	CLIMB SPEED KNOTS IAS
11,500	120
11,000	119
10,000	116
9000	113
8000	110

EXAMPLE:

OAT	4°C
PRESS. ALTITUDE	9000 FEET
WEIGHT	11,026 LBS
RATE-OF-CLIMB	206 FT/MIN
CLIMB SPEED	119 KNOTS IAS

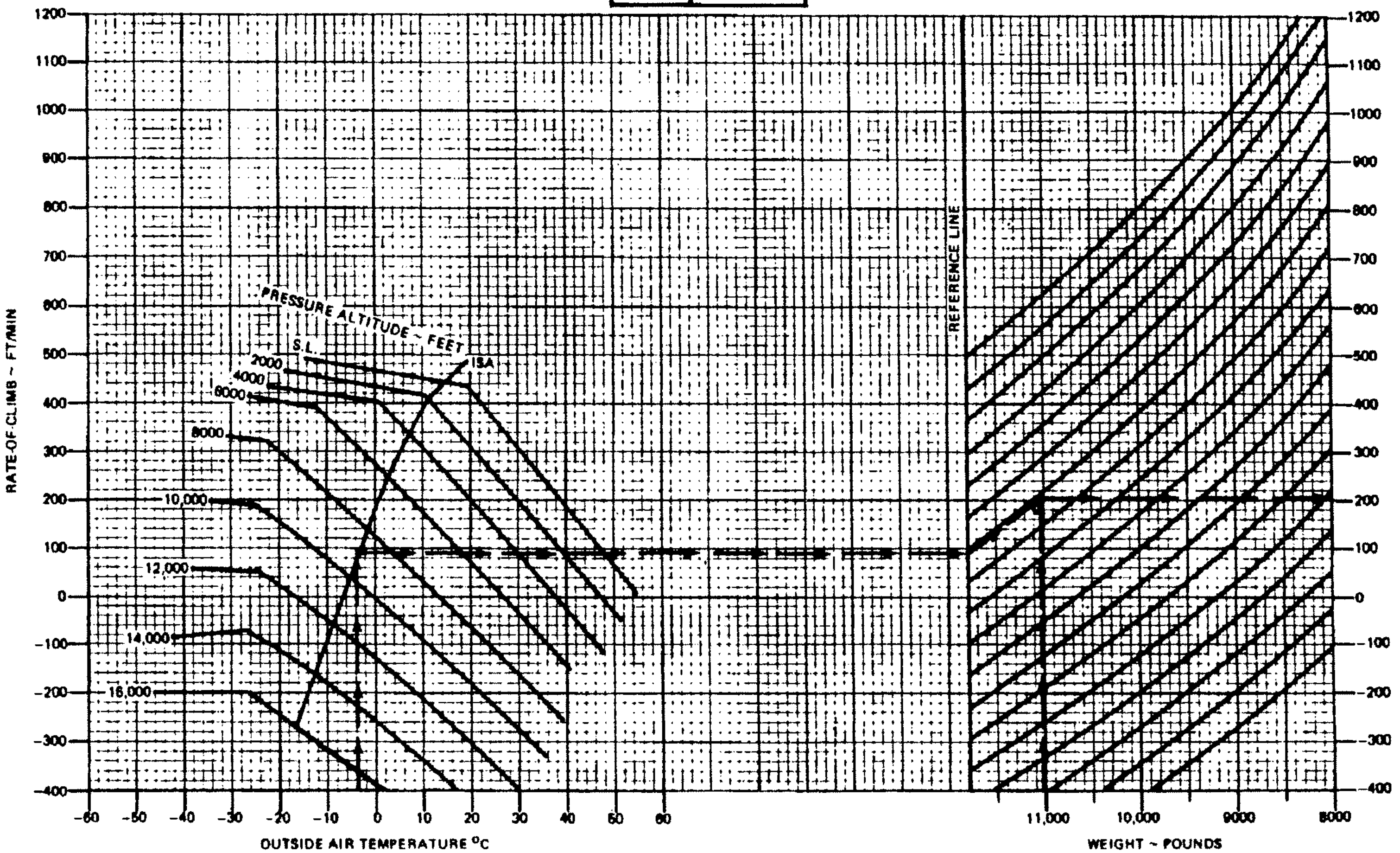


Figure 5-13

© 1996 General Aviation Manufacturers Association
Issued: February 15, 1975
Revised: October 18, 1996

RATE-OF-CLIMB - ONE ENGINE INOPERATIVE

ASSOCIATED CONDITIONS:

POWER	MAX. CONT. AT 2800 RPM
LANDING GEAR	UP
FLAPS	UP
PRESSURIZATION	OFF
INOPERATIVE PROPELLER	FEATHERED
FUEL MIXTURE	AT RECOMMENDED LEANING SCHEDULE.

EXAMPLE:

WEIGHT	4400	LBS
PRESSURE ALTITUDE	3000	FT
OUTSIDE AIR TEMPERATURE	10°C	
CLIMB SPEED	89	KIAS
RATE-OF-CLIMB	273	FT/MIN

WEIGHT LBS.	PRESSURE ALTITUDE FT	CLIMB SPEED KNOTS ~ IAS	RATE-OF-CLIMB - FT/MIN -20°C	0°C	20°C	40°C
4600	SL	90	430	375	320	255
	2000	90	340	285	230	170
	4000	89	260	200	145	95
	6000	89	165	110	55	0
	8000	88	75	26	-30	-85
	10000	88	-20	-75	-130	-185
4500	SL	88	645	490	435	380
	2000	88	455	405	350	300
	4000	87	365	310	260	210
	6000	87	275	220	165	116
	8000	86	186	130	75	26
	10000	86	95	40	-15	-70
4000	SL	86	685	630	575	520
	2000	86	590	550	485	430
	4000	84	495	445	390	340
	6000	84	400	345	290	245
	8000	82	310	250	200	150
	10000	82	210	155	100	50

Figure 5-14

© 1996 General Aviation Manufacturers Association

SERVICE CEILING — ONE ENGINE INOPERATIVE

ASSOCIATED CONDITIONS:		EXAMPLE:	
POWER	MAXIMUM CONTINUOUS	OAT AT MEA	10°C
LANDING GEAR	UP	ROUTE SEGMENT MEA	11,400 FEET
BLEED AIR VALVE	CLOSED		
INOPERATIVE PROPELLER	FEATHERED	WEIGHT	10,200 LBS
FLAPS	UP		

NOTE: SERVICE CEILING IS THE PRESSURE ALTITUDE WHERE AIRPLANE HAS CAPABILITY OF CLIMBING 50 FT/MINUTE WITH ONE PROPELLER FEATHERED.

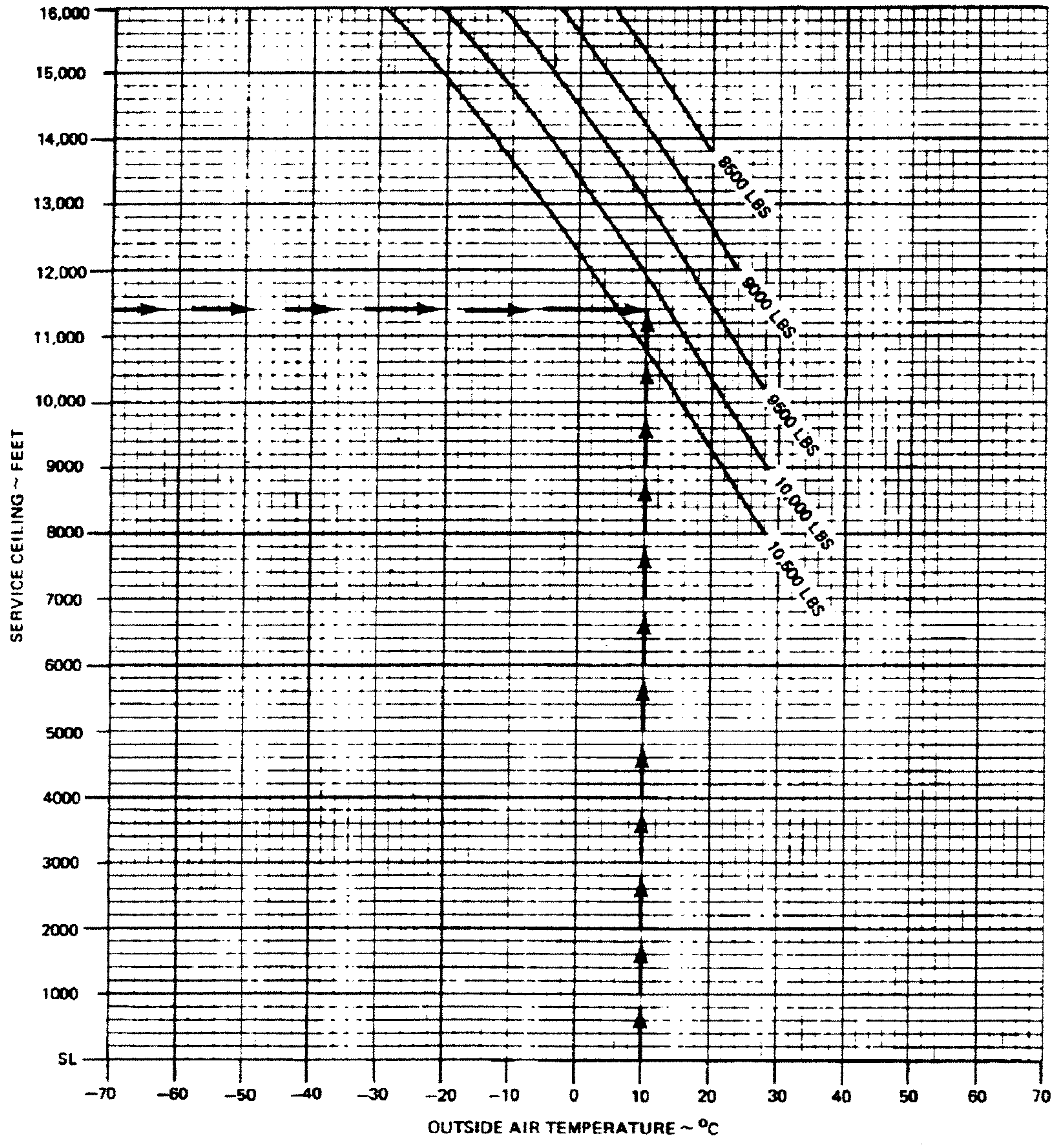


Figure 5-15

© 1996 General Aviation Manufacturers Association

SERVICE CEILING - ONE ENGINE INOPERATIVE

ASSOCIATED CONDITIONS:

POWER	MAX. CONTINUOUS
FLAPS	UP
LANDING GEAR	UP
BLEED AIR VALVE	CLOSED
INOPERATIVE PROPELLER	FEATHERED

EXAMPLE:

OAT AT MEA	-5°C
ROUTE SEGMENT MEA	8500 FT
WEIGHT	4305 LBS

NOTE:

SERVICE CEILING IS ALTITUDE WHERE AIRCRAFT HAS CAPABILITY OF CLIMBING 50 FT/MIN WITH ONE ENGINE FEATHERED.

PRESSURE ALTITUDE FEET	OUTSIDE AIR TEMPERATURE ∿ °C					
	-20	-10	0	10	20	30
	WEIGHT ∿ POUNDS					
4000	4600	4600	4600	4600	4600	4600
5000	4600	4600	4600	4600	4600	4520
7000	4600	4600	4510	4400	4290	4190
8000	4560	4450	4340	4230	4120	4020
9000	4380	4270	4160	4060	3950	3860
10000	4200	4100	3990	3900	----	----
11000	4020	3920	3820	----	----	----
12000	3950	----	----	----	----	----
13000	----	----	----	----	----	----
14000	----	----	----	----	----	----

Figure 5-16

© 1996 General Aviation Manufacturers Association

TIME, FUEL, AND DISTANCE TO CLIMB

WEIGHT POUNDS	CLIMB SPEED KNOTS IAS
3300 2800	130 130

ASSOCIATED CONDITIONS:

POWER	2625 RPM, FULL THROTTLE
MIXTURE	FULL RICH
TEMPERATURE	STANDARD DAY (ISA)
FUEL DENSITY	6.0 LBS/GAL

EXAMPLE:

AIRPORT ALTITUDE	2600 FEET
CRUISE ALTITUDE	8600 FEET
TIME TO CLIMB (17 - 3.5)	13.5 MINUTES
FUEL TO CLIMB (180 - 43)	137 LBS
DISTANCE TO CLIMB (46.5 - 9.5)	37.0 N M

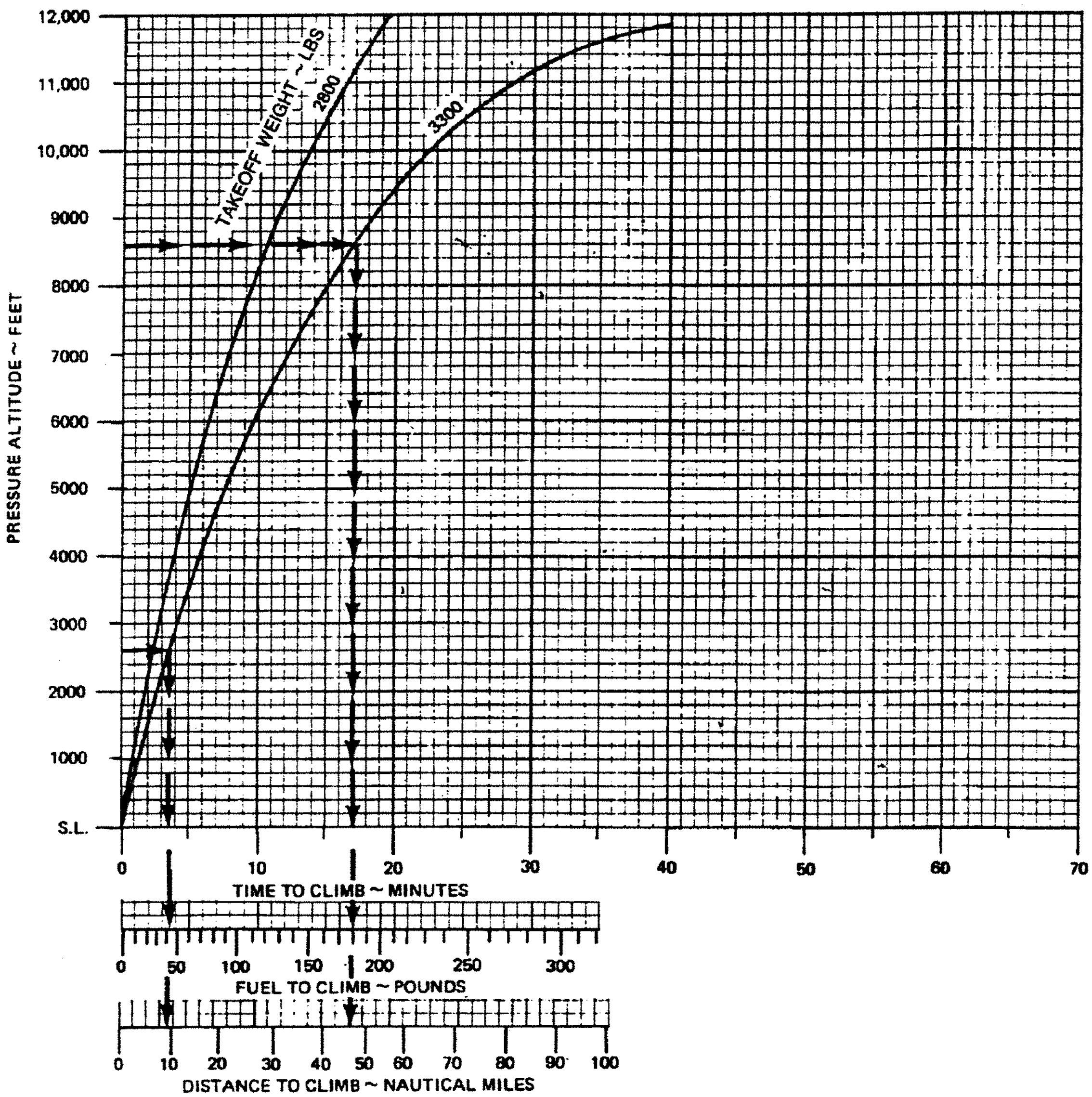


Figure 5-17

© 1996 General Aviation Manufacturers Association

TIME, FUEL, AND DISTANCE TO CLIMB

ASSOCIATED CONDITIONS:

POWER	MAX. M.P. AT 2700 RPM
FUEL MIXTURE	RECOMMENDED LEANING SCHEDULE
FUEL DENSITY	6.0 LBS/GAL
FLAPS	0%
TEMPERATURE	STANDARD DAY (ISA) (SEE NOTE 2, FOR APPROX. PERFORMANCE ABOVE ISA)

EXAMPLE:

ALTITUDE	17,500 FT
WEIGHT	3,350 LBS
INDICATED AIR SPEED	89 KIAS
RATE-OF-CLIMB	765 FT/MIN
TIME	23 MIN
FUEL	61 LBS
DISTANCE	40 N.M.

NOTES:

1. DISTANCES SHOWN ARE BASED ON ZERO WIND.
2. FOR TEMPERATURES ABOVE STANDARD, DECREASE RATE-OF-CLIMB 40 FT/MIN FOR EACH 5°C ABOVE STANDARD DAY TEMPERATURE FOR PARTICULAR ALTITUDE.

PRESSURE ALTITUDE	CLIMB SPEED	WEIGHT	RATE OF CLIMB	FROM SEA LEVEL		
				TIME	FUEL USED	DISTANCE
FT	KIAS	LBS	FT/MIN	MIN	LBS	N.M.
SEA LEVEL	90	3600	1030	0	12	0
		3100	1300	0	12	0
		2600	1660	0	12	0
5,000	90	3600	950	5	30	9
		3100	1220	4	24	7
		2600	1570	3	18	8
10,000	90	3600	860	11	42	20
		3100	1120	8	36	16
		2600	1470	6	30	12
15,000	90	3600	740	18	60	35
		3100	1000	14	31	28
		2600	1320	10	43	20
20,000	88	3600	540	37	84	55
		3100	780	20	68	40
		2600	1080	14	46	30
25,000	84	3600	190	13	120	95
		3100	330	29	92	65
		2600	630	20	63	45

Figure 5-18

© 1996 General Aviation Manufacturers Association

TIME, FUEL, AND DISTANCE TO CLIMB

ASSOCIATED CONDITIONS:

PROPELLER SPEED	2000 RPM
ITT	710°C
OR TORQUE	1628 FT LBS

ALTITUDE ~ FEET	CLIMB SPEED KNOTS IAS
S.L. TO 10,000	150
10,000 TO 20,000	130
20,000 TO 25,000	120
25,000 TO 30,000	110

EXAMPLE:

OAT AT TAKEOFF	25°C
OAT AT CRUISE	0°C
AIRPORT PRESSURE ALTITUDE	4000 FEET
CRUISE ALTITUDE	16,000 FEET
INITIAL CLIMB WEIGHT	11,500 LBS
TIME TO CLIMB (17 - 3.5)	13.5 MINUTES
FUEL TO CLIMB (180 - 44)	136 LBS
DISTANCE TO CLIMB (46.5 - 9.5)	37.0 NM

NOTE: ADD 68 LBS FOR START, TAXI, AND TAKEOFF

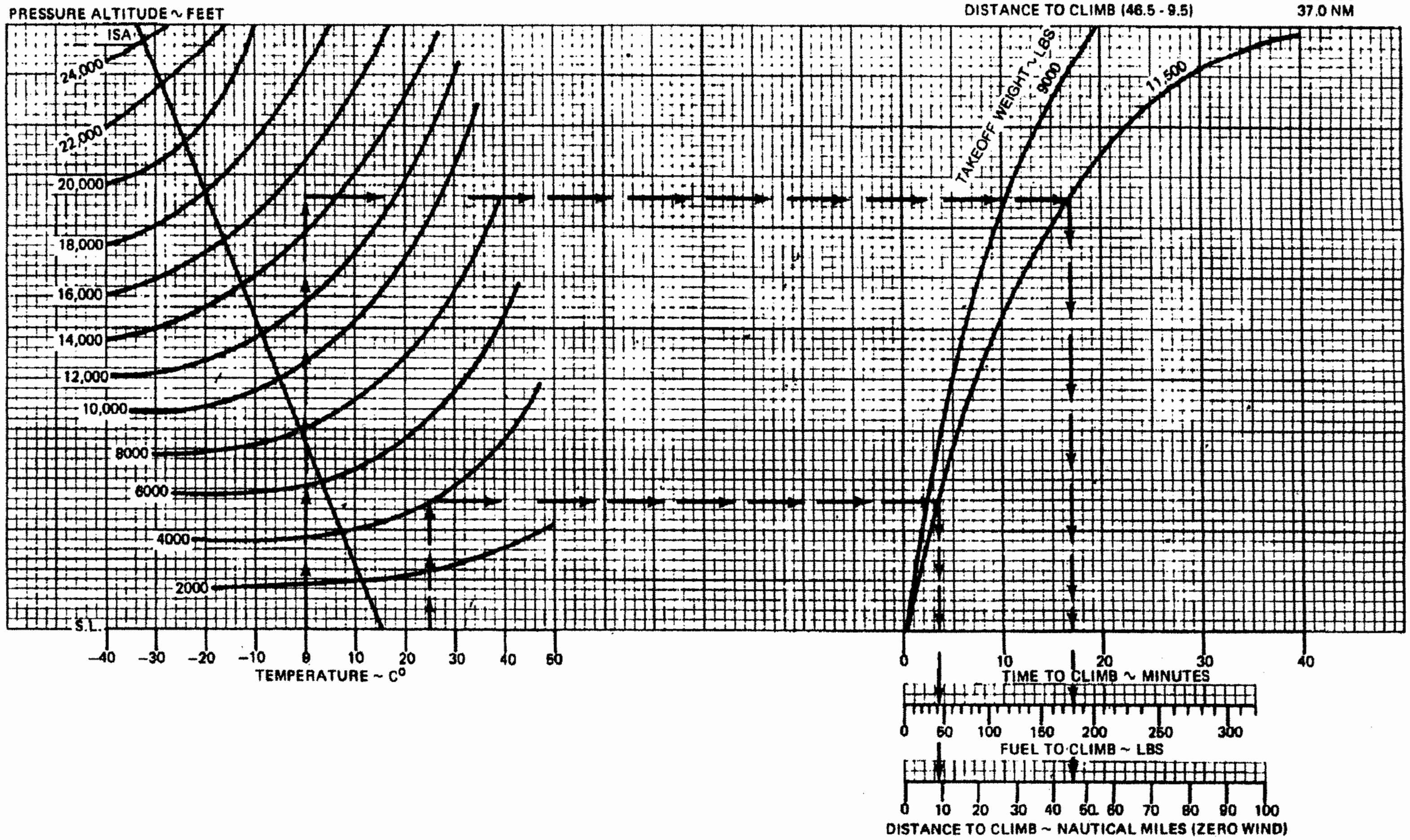


Figure 5-19

© 1996 General Aviation Manufacturers Association
Issued: February 15, 1975
Revised: October 18, 1996

TIME, FUEL, AND DISTANCE TO CLIMB

ASSOCIATED CONDITIONS:

POWER	MAX. M.P. AT 2275 RPM
FUEL MIXTURE	RECOMMENDED LEAN
LANDING GEAR	UP
FLAPS	0%

EXAMPLE:

OAT AT TAKEOFF	ISA + 6°C
OAT AT CRUISE	ISA - 2°C
AIRPORT PRESSURE ALTITUDE	4000 FT
CRUISE ALTITUDE	15000 FT
INITIAL CLIMB WEIGHT	11500 LBS
TIME TO CLIMB (12-3)	9 MIN
FUEL TO CLIMB (141-37)	104 LBS
DISTANCE TO CLIMB (34-8)	26 N.M.

NOTE:

1. DISTANCES SHOWN ARE BASED ON ZERO WIND.
2. ADD 68 LBS. OF FUEL FOR START, TAXI AND TAKEOFF.

PRESSURE ALTITUDE FT	CLIMB SPEED KIAS	TAKEOFF WEIGHT LBS	TEMPERATURE								
			ISA + 10°C			ISA			ISA - 10°C		
			FROM SEA LEVEL								
			TIME MIN	FUEL LBS	DIST NM	TIME MIN	FUEL LBS	DIST NM	TIME MIN	FUEL LBS	DIST NM
SEA LEVEL	150	11,500	0	0	0	0	0	0	0	0	0
		8,000	0	0	0	0	0	0	0	0	0
4,000	150	11,500	3	39	8	3	34	7	2	31	7
		8,000	2	26	6	2	24	5	2	23	5
8,000	150	11,500	6	76	17	5	67	15	5	62	14
		8,000	4	53	12	4	47	10	3	41	9
12,000	130	11,500	11	127	30	9	107	24	8	98	22
		8,000	7	85	20	6	73	17	5	65	15
16,000	130	11,500	17	182	47	14	156	38	12	138	33
		8,000	11	122	28	9	107	24	8	96	22
20,000	120	11,500	29	278	81	21	215	59	18	192	51
		8,000	16	105	44	13	147	35	11	129	30
24,000	120	11,500		0	0	36	320	101	30	285	84
		8,000	21	216	59	19	195	52	17	182	47

Figure 5-20

© 1996 General Aviation Manufacturers Association

INTENTIONALLY LEFT BLANK

© 1996 General Aviation Manufacturers Association

FUEL AND TIME REQUIRED

70% POWER

CONDITIONS:
5150 Pounds
Recommended Lean Mixture for Cruise
Standard Temperature

NOTE:
Fuel required includes the fuel used for engine start, taxi, takeoff, normal climb, descent and 45 minutes reserve. Time required includes the time during a normal climb and descent.

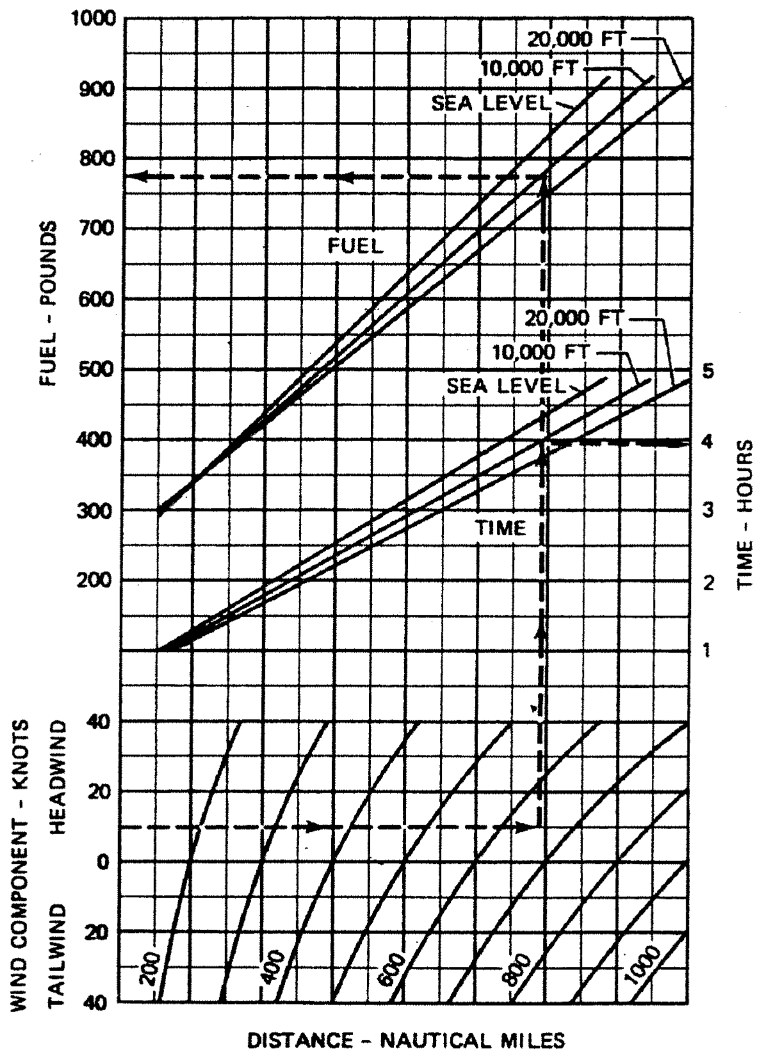


Figure 5-20A

© 1996 General Aviation Manufacturers Association

RANGE PROFILE

STANDARD DAY

ASSOCIATED CONDITIONS:

WEIGHT	9705 LBS BEFORE ENGINE START
FUEL	AVIATION KEROSENE
FUEL DENSITY	6.7 LBS/GAL
INITIAL FUEL LOADING	384 U. S. GAL (2573 LBS)
PROPELLER SPEED	1900 RPM

NOTE: RANGE INCLUDES START, TAXI, CLIMB AND DESCENT WITH 45 MINUTES RESERVE FUEL AT MAXIMUM RANGE POWER.

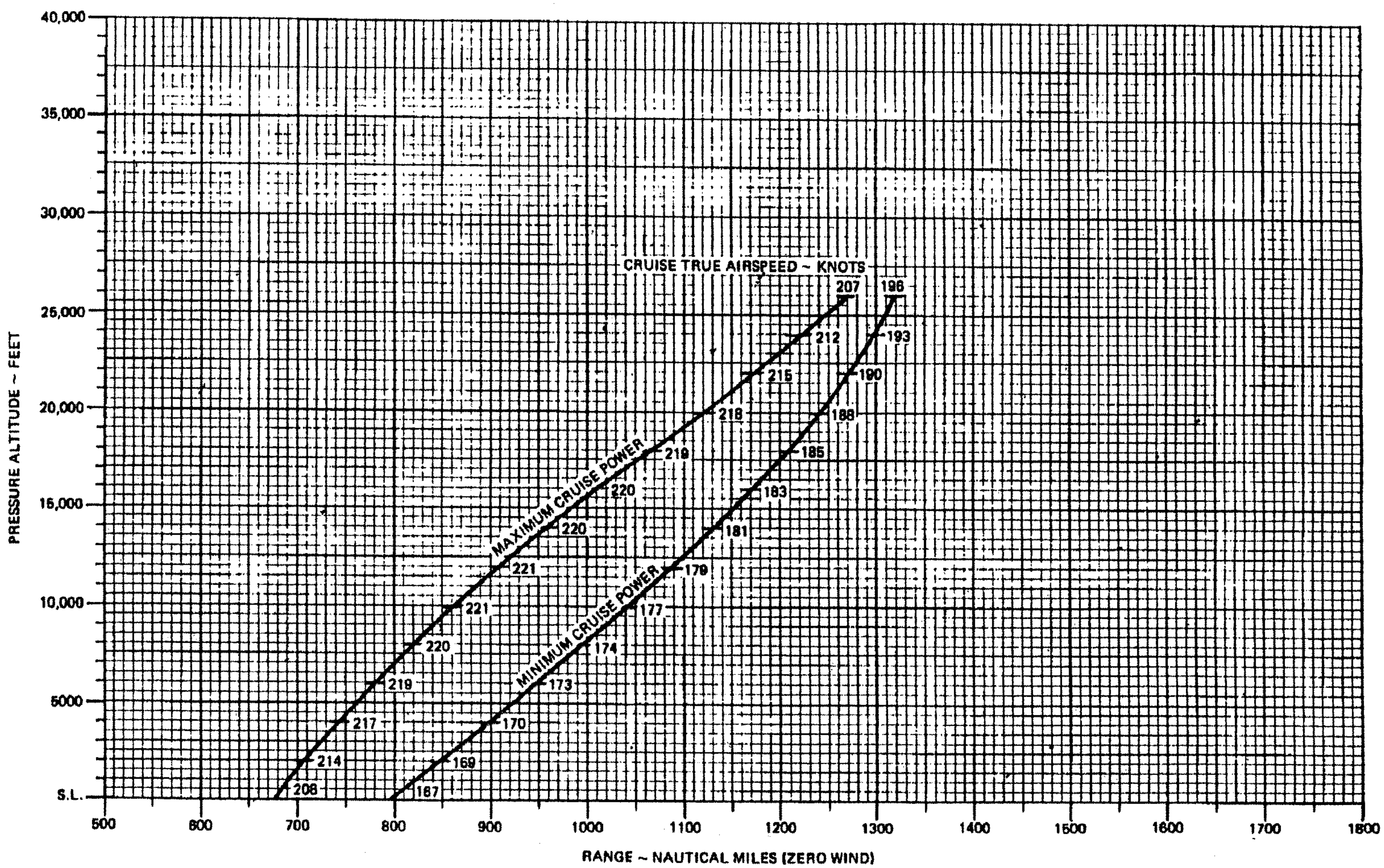


Figure 5-21

© 1996 General Aviation Manufacturers Association
Issued: February 15, 1975
Revised: October 18, 1996

ENDURANCE PROFILE

STANDARD DAY

ASSOCIATED CONDITIONS:

WEIGHT	9706 LBS BEFORE ENGINE START
FUEL	AVIATION KEROSENE
FUEL DENSITY	6.7 LBS/GAL
INITIAL FUEL LOADING	384 U. S. GAL (2573 LBS)
PROPELLER SPEED	1900 RPM

NOTE: ENDURANCE INCLUDES START, TAXI, CLIMB AND DESCENT WITH 45 MINUTES RESERVE FUEL AT MAXIMUM RANGE POWER.

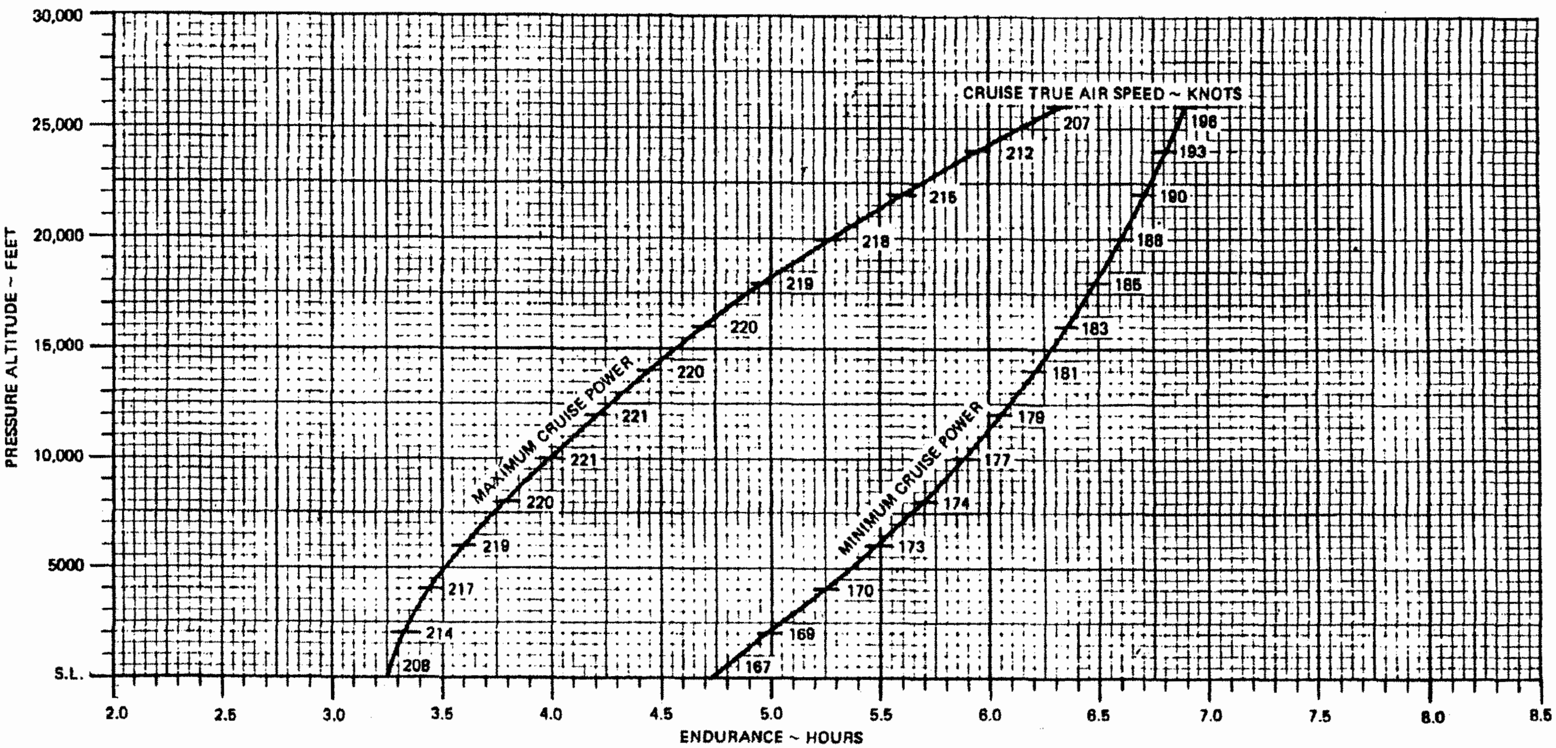


Figure 5-22

© 1996 General Aviation Manufacturers Association

HOLDING TIME

ASSOCIATED CONDITIONS:

TORQUE SETTING	650 FT LBS
PROPELLER SPEED	1900 RPM

EXAMPLES:

❶ FUEL AVAILABLE FOR HOLDING	440 LBS
PRESSURE ALTITUDE	6000 FEET
HOLDING TIME	1.1 HOURS (1 HR, 6 MIN)
❷ REQUIRED HOLDING TIME	45 MINUTES (.75 HRS)
HOLDING PRESSURE ALTITUDE	8000 FEET
FUEL REQUIRED	295 LBS

NOTE: APPLICABLE FOR ALL TEMPERATURES

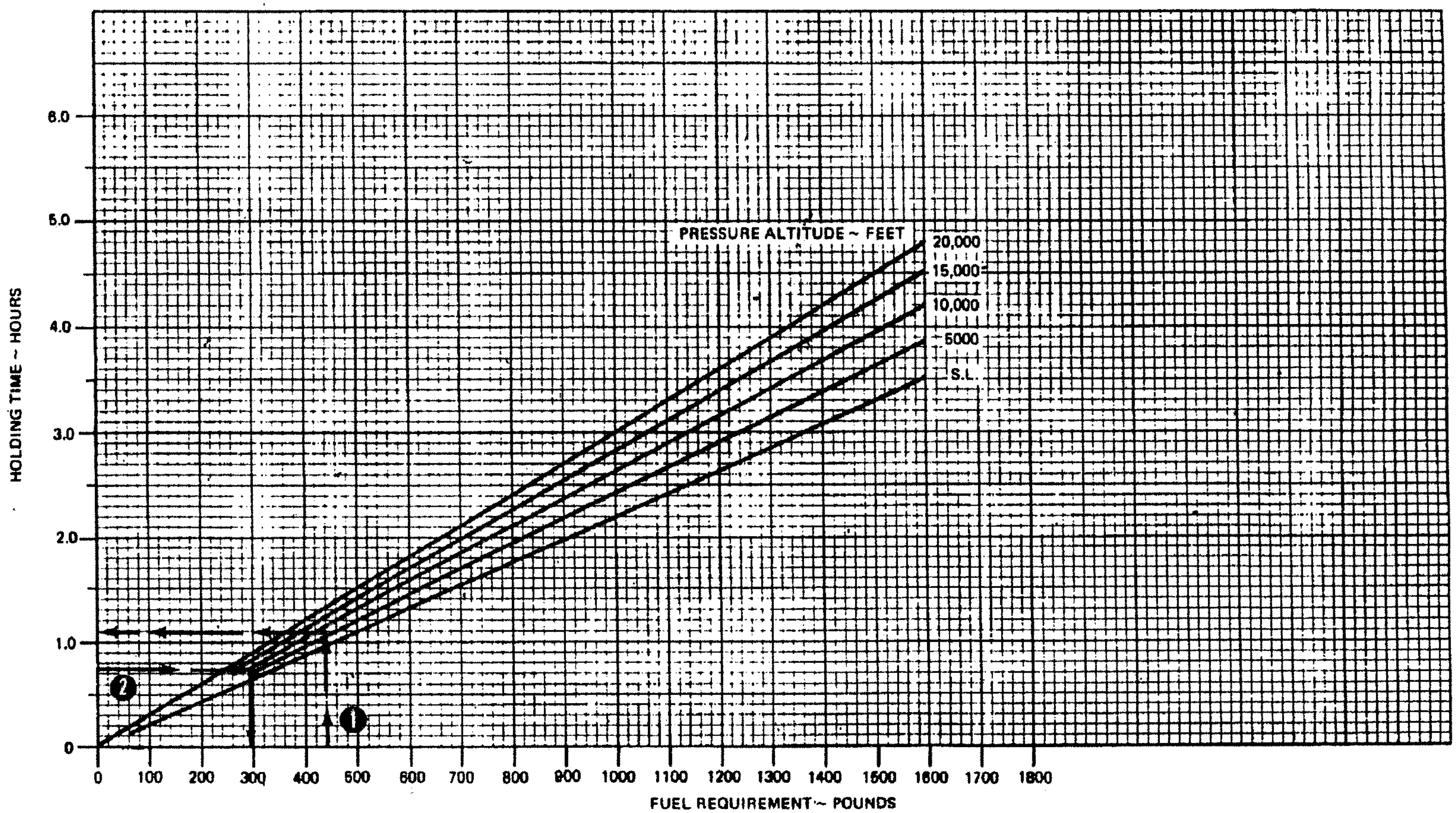


Figure 5-23

© 1996 General Aviation Manufacturers Association

HOLDING TIME

ASSOCIATED CONDITIONS:

TORQUE SETTING	650 FT LBS
PROPELLER SPEED	1900 RPM

EXAMPLES:

1.	FUEL AVAILABLE FOR HOLDING	440 LBS
	PRESSURE ALTITUDE	6000 FT
	HOLDING TIME	1.04 HRS (1 HR, 2 MIN)
2.	REQUIRED HOLDING TIME	45 MIN (.75 HRS)
	HOLDING PRESSURE ALTITUDE	8000 FT
	FUEL REQUIRED	319 LBS

FUEL REQUIREMENT/ OR AVAILABLE ∿ POUNDS	HOLDING TIME ∿ HRS			
	PRESSURE ALTITUDE ∿ FEET			
	S.L.	5000	10000	15000
100	.2	.2	.2	.3
200	.4	.4	.5	.6
300	.6	.7	.7	.8
400	.8	.9	1.0	1.1
500	1.1	1.2	1.3	1.4
600	1.3	1.4	1.5	1.7
700	1.5	1.7	1.8	1.9
800	1.7	1.9	2.1	2.2
900	1.9	2.1	2.3	2.5
1000	2.2	2.4	2.6	2.8
1100	2.4	2.6	2.9	3.1
1200	2.6	2.9	3.1	3.4
1300	2.8	3.1	3.4	3.6
1400	3.0	3.3	3.6	3.9
1500	3.3	3.6	3.9	4.2
1600	3.5	3.8	4.2	4.5

Figure 5-24

© 1996 General Aviation Manufacturers Association

TIME, FUEL, AND DISTANCE TO DESCEND

ALTITUDE ~ FEET	DESCENT SPEED KNOTS IAS
31,000 TO 20,000	180
20,000 TO S.L.	200

ASSOCIATED CONDITIONS:

POWER	AS REQUIRED TO DESCEND AT 1000 FT/MIN
LANDING GEAR	UP
FLAPS	0%
PROPELLER SPEED	1900 RPM

EXAMPLE:

INITIAL ALTITUDE	17,000 FEET
FINAL ALTITUDE	5650 FEET
TIME TO DESCEND (17 - 5.8)	11 MINUTES
FUEL TO DESCEND (142 - 62)	80 LBS
DESCENT DISTANCE (65 - 20)	45 NM

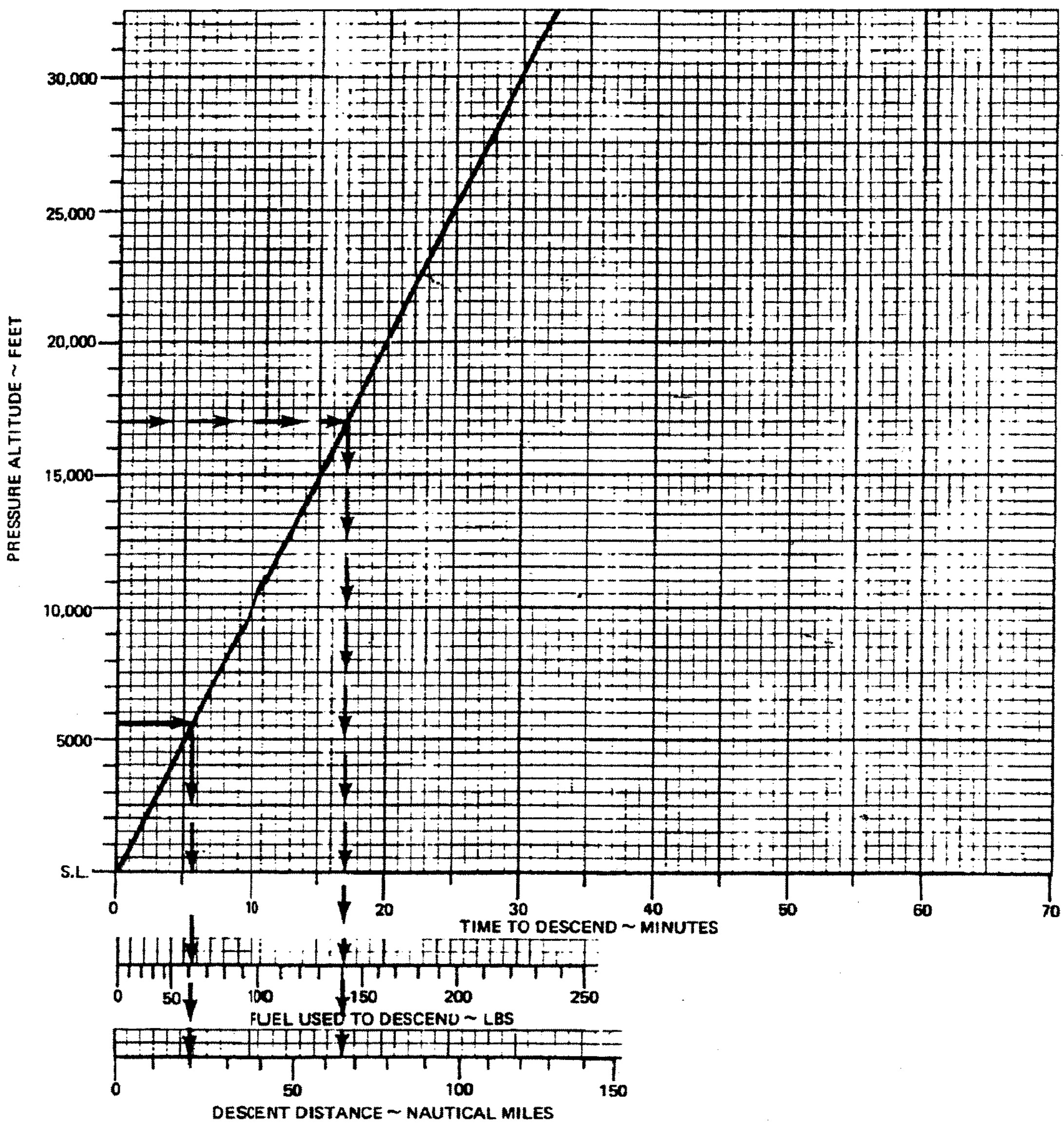


Figure 5-25

© 1996 General Aviation Manufacturers Association

TIME, FUEL, AND DISTANCE TO DESCEND

ASSOCIATED CONDITIONS:

POWER	AS REQ'D. FOR 1000 FPM
FLAPS	UP
LANDING GEAR	UP
AIRSPEED	200 KIAS

EXAMPLE:

INITIAL ALTITUDE	17,000 FT
FINAL ALTITUDE	5650 FT
TIME TO DESCEND (17-6)	11 MIN
FUEL TO DESCEND (143-62)	81 LBS
DISTANCE TO DESCEND (69-20)	49 N.M.

PRESSURE ALTITUDE FEET	TIME MIN	FUEL LBS	DISTANCE N.M.
30,000	30	223	118
25,000	25	197	97
20,000	20	163	88
15,000	15	130	57
10,000	10	95	36
5,000	5	57	18
SEA LEVEL	0	0	0

Figure 5-26

© 1996 General Aviation Manufacturers Association

LANDING DISTANCE
WITHOUT REVERSING

ASSOCIATED CONDITIONS:

POWER	RETARDED TO MAINTAIN 500 FT/MIN ON FINAL APPROACH
FLAPS	100%
RUNWAY	PAVED, LEVEL, DRY SURFACE
APPROACH SPEED	IAS AS TABULATED
BRAKING	MAXIMUM

WEIGHT POUNDS	SPEED AT 50 FEET KNOTS IAS
11,210	100
11,000	99
10,000	94
9000	90
8000	84

EXAMPLE:

OAT	15°C
PRESSURE ALTITUDE	5650 FEET
LANDING WEIGHT	10,301 LBS
HEADWIND COMPONENT	9.5 KNOTS
GROUND ROLL	1320 FEET
TOTAL OVER 50 FOOT OBSTACLE	2280 FEET
APPROACH SPEED	96 KNOTS IAS

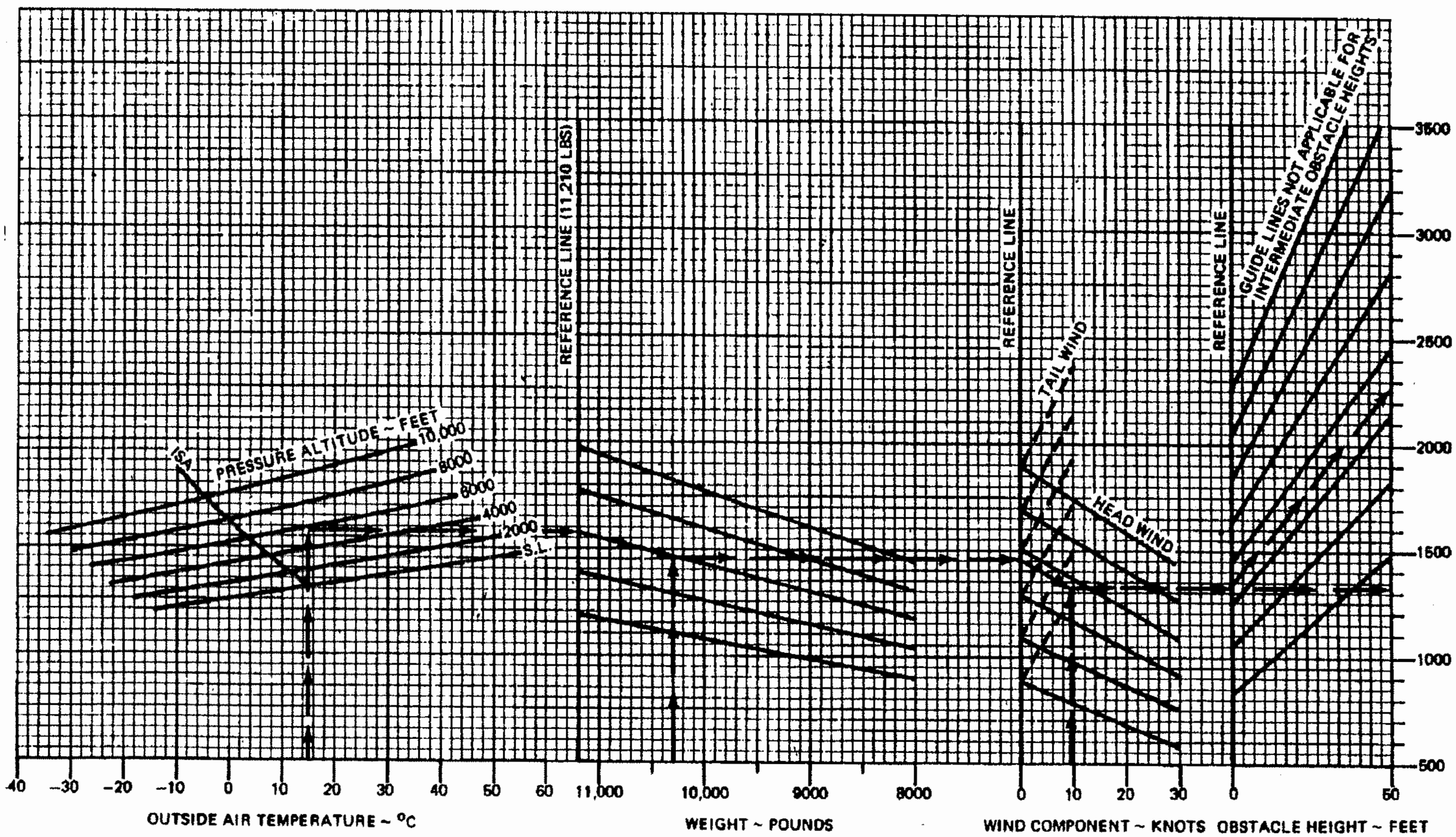


Figure 5-27

© 1996 General Aviation Manufacturers Association

LANDING DISTANCE

ASSOCIATED CONDITIONS:

POWER	RETARDED TO MAINTAIN 500 FT/MIN ON FINAL APPROACH
FLAPS	100%
RUNWAY	PAVED, LEVEL, DRY SURFACE
BRAKING	MAXIMUM

EXAMPLE:

WEIGHT	10301 LBS
OUTSIDE AIR TEMPERATURE	15°C
PRESSURE ALTITUDE	5650 FT
HEADWIND COMPONENT	9.5 KTS
GROUND ROLL	1333 FT
TOTAL OVER 50 FT OBSTACLE	2249 FT
APPROACH SPEED	95 KIAS

NOTE:

1. DECREASE DISTANCES 4% FOR EACH 5 KNOTS HEADWIND.
   FOR OPERATIONS WITH TAILWINDS UP TO 10 KNOTS, INCREASE DISTANCES BY 6% FOR EACH 2.5 KNOTS.

WEIGHT LBS	SPEED AT 50 FT KIAS	PRESS ALT FEET	0°C		10°C		20°C		30°C		40°C	
			GROUND ROLL	TOTAL TO CLEAR 50 FT OBS	GROUND ROLL	TOTAL TO CLEAR 50 FT OBS	GROUND ROLL	TOTAL TO CLEAR 50 FT OBS	GROUND ROLL	TOTAL TO CLEAR 50 FT OBS	GROUND ROLL	TOTAL TO CLEAR 50 FT OBS
11210	100	SL	1250	2140	1275	2160	1300	2200	1350	2260	1410	2360
		2000	1325	2270	1380	2300	1420	2340	1455	2410	1490	2320
		4000	1425	2365	1455	2420	1490	2490	1550	2570	1600	2685
		6000	1525	2575	1570	2630	1610	2705	1660	2790	1720	2900
		8000	1625	2750	1675	2825	1730	2920	1800	3065	----	---
		10000	1750	2975	1800	3140	1860	3265	1900	3370	----	---
11000	99	SL	1235	2085	1250	2140	1280	2200	1320	2275	1380	2380
		2000	1300	2200	1340	2260	1390	2320	1430	2390	1485	2485
		4000	1400	2360	1440	2420	1475	2480	1520	2500	1560	2540
		6000	1490	2550	1540	2600	1580	2695	1630	2800	1700	2900
		8000	1610	2690	1650	2800	1700	2900	1760	3030	----	----
		10000	1720	2925	1760	3060	1850	3070	1900	3290	----	----
10000	94	SL	1125	1925	1150	1980	1180	2030	1220	2085	1270	2160
		2000	1200	2050	1225	2075	1250	2120	1285	2180	1885	2250
		4000	1300	2200	1315	2250	1340	2300	1375	2350	1440	2430
		6000	1370	2300	1400	2350	1430	2400	1480	2470	2550	2520
		8000	1460	2450	1500	2490	1540	2580	1610	2730	----	---
		10000	1580	2650	1610	2800	1660	2925	1740	3025	----	---

Figure 5-28

© 1996 General Aviation Manufacturers Association

SINGLE ENGINE AIRPLANES
IDENTIFICATION OF GRAPHS OR TABLES
IN TYPICAL ORDER OF PRESENTATION
INCLUDING OPTIONAL ITEMS

ORDER	*TITLE*
1	Introduction to Performance and Flight Planning
2	Airspeed Calibration
3	Altimeter Correction
* 4	Fahrenheit to Celsius Temperature Conversion
5	Stall Speeds
6	Takeoff Distance
* 7	Minimum Takeoff Distance
8	Rate-of-Climb
9	Time, Fuel and Distance to Climb
10	Cruise
*11	Cruise Speeds
*12	Fuel Flow vs Brake Horsepower
13	Fuel and Time Required
14	Range Profile
15	Endurance Profile
16	Landing Distance

* Optional items may be required by regulation for some airplane models.

Figure 5-29

© 1996 General Aviation Manufacturers Association
Issued: February 15, 1975
Revised: October 18, 1996

MULTI- ENGINE AIRPLANES
IDENTIFICATION OF GRAPHS OR TABLES
IN TYPICAL ORDER OF PRESENTATION
INCLUDING OPTIONAL ITEMS

ORDER	TITLE
1	Introduction to Performance and Flight Planning
2	Airspeed Calibration-Normal System
3	Airspeed Calibration-Alternate System (If Applicable)
4	Altimeter Correction-Normal System
5	Altimeter Correction-Alternate System (If Applicable)
* 6	Indicated Outside Air Temperature Correction
* 7	Fahrenheit to Celsius Temperature Conversion
* 8	Terrain Clearance Limitations
9	Stall Speeds
15	Takeoff Distance
*16	Minimum Takeoff Distance
17	Accelerate-Stop Distance
* 18	Accelerate-Go Distance
19	Rate-of-Climb-All Engines Operating (Flaps set to take-off position)
*20	Climb Gradient-One Engine Inoperative (Flaps set to take-off position)
*21	Rate-of-Climb-All Engines Operating (Flaps set to enroute position)
22	Time, Fuel and Distance to Climb
23	Rate-of-Climb-One Engine Inoperative (Flaps set to enroute position)
24	Service Ceilings-One Engine Inoperative
25	Rate-of-Climb-Balked Landing
26	Cruise-All Engines Operating
*27	Cruise Speeds-Maximum Recommended Cruise Power-All Engines Operating
28	Fuel and Time Required
29	Range Profile
*30	Range Payload Trade-Off-All Engines Operating
31	Endurance Profile
*32	Cruise Performance-One Engine Inoperative
33	Holding Time
*34	Pressurization Controller Setting for Landing
35	Landing Distance

*Optional items may be required by regulation for some airplane models.

Figure 5-30

For the remaining 72 pages, download the Specification here:
https://gama.aero/documents/gama-specification-1-specification-for-pilots-operating-handbook-version-2-0/

© 1996 General Aviation Manufacturers Association