SPECIFICATION FOR PILOT'S OPERATING HANDBOOK

GAMA Specification No. 1
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Limited Review

for commentary and teaching purposes

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

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– Committed to Improve Aviation Safety –

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

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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

[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 Chapter, 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.

jets, helicopters, and simulators. They 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.

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 this and other POH/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], nor as used during airplane design, during experimental flight testing, nor as taught at aeronautical universities for airplane design and Test Pilot Schools. 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 POH/AFM to become aware of the real values of the used airspeeds. Misuse of the CAS and IAS in POH/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[11] 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 speed 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.

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

[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] *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.

reference, rather than the ambient pressure and temperature. CAS makes the flying task and the use of pre-determined performance data a lot more convenient.
TAS is calculated from CAS using both the actual ambient pressure altitude and the outside air temperature, using an E6-B flight computer or by on-board computers.
A proper definition of True Airspeed (TAS) is:

TAS is the true airspeed with respect to the ambient pressure and temperature

3.2.3. **Calibrated Air Speed** (CAS, or V_C) is the airspeed (velocity) of the airplane in undisturbed air which should be measured by a long pitot-static boom that sticks out in front of the bow wave, which however, is not practical. Therefore, the required air pressures to determine the CAS is measured by a pitot tube mounted on the fuselage or wings, in disturbed air, which measures the total pressure (P_T), and by a flush port which measures the ambient (static) pressure (P_a), as shown in Figure 1. The consequence of the placement of the pressure sensors in disturbed air and on the fuselage are errors in the pressure measurement, called position errors. The errors are determined during in-flight **calibration** over a range of airspeeds (and altitudes) and are furnished as position error in graphs in the POH/AFM.

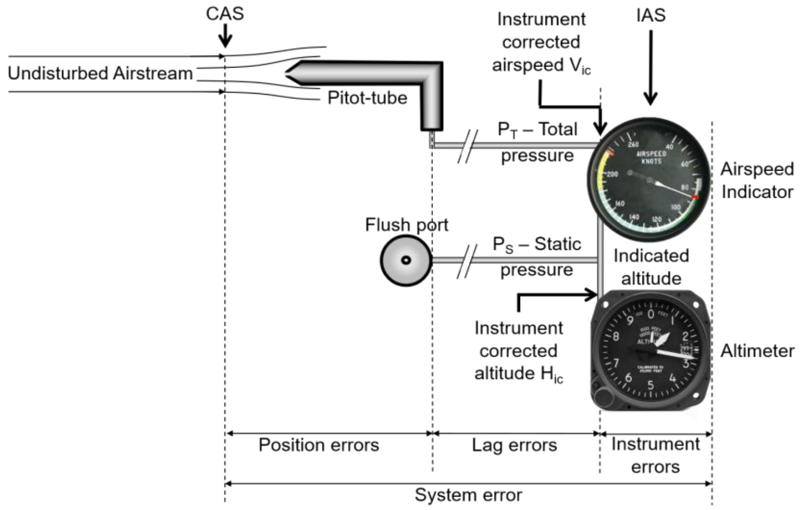

Figure 1. A common Pitot-static system and its errors; from Calibrated Airspeed (CAS) in undisturbed airstream to Indicated Airspeed (IAS) on the Airspeed Indicator (ASI).

Both air pressures are fed to one or more Air Speed Indicators (ASI) which measure the difference between P_T and P_a, also called dynamic pressure (q_c). ASIs are constructed to display the *airspeed with respect to the standard atmospheric pressure* (P_{SL}) *and density* (ρ_{SL}) *at sea level* (Figure 2), which are the references for CAS as already mentioned above. The only variable is the differential pressure q_c, which is $P_T - P_a$. An ASI has errors too, the instrument errors, as shown in Figure 1 and requires **calibration** as well, which will be discussed below.

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

Figure 2. Calibrated Airspeed (CAS, V_c) equation.

At a constant q_c, the CAS will always be the same. Hence CAS on one day is CAS on another day; changes in pressure and temperature will not affect CAS under these conditions.
CAS is convenient for the piloting task (as compared to TAS); the POH/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 a POH/AFM. CAS cannot directly be displayed in the cockpit because of the errors, but must be calculated by the pilot by adding both the ASI instrument error and the pitot-static position error to the airspeed indicated by the Airspeed Indicator (ASI). The errors can be positive, zero

or negative. The CAS of two airplanes flying in formation should be equal, while their IAS are most probably not. CAS is often inappropriately explained as being the abbreviation of Computed Air Speed, even by accident investigators.
A proper definition of Calibrated Airspeed (CAS) is:

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

The use of CAS allows the manufacturer or operator to use (copies of) the same POH/AFM for a series of airplanes of the same type that have identical pitot-static systems (position errors). The FAA or equivalent authority then only must approve one POH/AFM.

The air data computer in modern electronic display systems should be calibrated to display CAS on the airspeed display, for the pilot to be able to relate directly with limiting and operational speeds and with performance data which are determined and published as CAS in the POH/AFM.

The TAS of the airplane is to be calculated using CAS and both the ambient pressure and the ambient temperature (using an E6-B computer or equivalent). As the standard atmospheric pressure and density (temperature) at sea level were used as a reference for the CAS, TAS is equal to CAS at sea level in a standard atmosphere.

3.2.4. **The Indicated airspeed** (IAS) is the airspeed indicated or displayed on an Airspeed Indicator (ASI). An ASI is simple in design and construction and easy to calibrate, but also has unavoidable errors, called instrument errors. 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 report (small table) and furnished to the pilot. If more than one ASI is installed in a cockpit, the airspeed indicated on each ASI might not be equal, due to different (allowed) errors in each individual ASI. 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 POH/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 an POH/AFM.

IAS is equal to CAS plus both the position and the instrument errors, which can be positive or negative. The position error of the pitot-static system (≤ 5 kt) is presented in the POH/AFM; the instrument error of each individual ASI (≤ 4 kt) must be furnished to the pilot separately, as required by FAR 23. An indicated airspeed of 80 KIAS can be only 71 KCAS, the speed at which the airplane is plowing the air, when the errors are maximum approved.
The pilot must calculate limiting and operational speeds provided in the POH/AFM from CAS to IAS for use in the cockpit, and calculate CAS from IAS for looking up required performance data in the POH/AFM. As noticed during reviews of manuals, many if not all POH/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 the CAS when corrected for the position and instrument errors

3.2.5. **Ground Speed (GS).** The flow of the airmass through the atmosphere, being 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

3.2.6. **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 11 on page 7 for further explanation.

3.2.7. **Pitot-Static system**. The airspeed measuring system is illustrated in Figure 1 above. The airspeed in front of the tip of the pitot-tube in the undisturbed free airstream is the CAS of the airplane; the ASI displays the IAS to the pilot. The system errors consist of position, lag, and instrument errors which will be discussed briefly below.

3.2.8. ***Position Error*.** The position error is the error caused by positioning the pitot-tube and flush ports on the fuselage, rather than in the undisturbed free airstream. The error is influenced by the local pressure at the pitot-tube and flush port 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"*. The pitot-static system error must be and is published as position error in the POH/AFM of the airplane.

3.2.9. ***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.

3.2.10. ***Instrument Errors***. 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 2).
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 available for free. 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 instrument correction of each ASI and the (common) position error correction of the pitot-static system, are equal.

3.2.11. The pressure difference P_T minus P_a (or P_S) at the entrance of the ASI is a measure of the IAS plus the instrument error, and is also called the *instrument corrected airspeed* Vic (Figure 1), which is to be used as the entry variable for the position error chart published in the POH/AFM.

3.2.12. *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 into digital data for further processing and display. Such a system however, still has the errors as shown in Figure 1. A computerized air data system should allow for entry of calibration corrections to compensate for position and lag 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. The piloting task becomes more convenient; the indicated airspeed has become the calibrated airspeed. In most older airplanes though, the pilot still must work with both the position and instrument errors and hence with both CAS and IAS.

3.2.13. ***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 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.

3.2.14. The altimeter errors were not mentioned, but are also addressed in FAR 23. The calibration is required in FAR § 23.1325(e). Refer to the coursebook in footnote 11.

3.2.15. Refer to the (free) book *Pitot-Statics and the Standard Atmosphere* in footnote 11 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. As mentioned in § 2.1.1, GAMA Specification is originally intended for Normal Category Airplanes, it is also used for Commuter Class POH/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.

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 by an incompetent pilot. 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 POH/AFM data tables and/or graphs, and correct these to IAS by applying both the position error in the POH/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 card for use in the cockpit. Presenting IAS in an AFM that is for a series of airplanes is impossible and asking for fatal accidents; 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 POH/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 a POH/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 POH/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 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 above in § 3.3.4 above, the pilot must calculate the IAS values and present these on a takeoff and landing data card for use in the cockpit.

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".*
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 (§ 3.2.11). 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 2). 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 1 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 a POH/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 POH/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 POH/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 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 POH/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 POH/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 POH/AFM applies, are known to the POH/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 a POH/AFM requires a separate POH/AFM for each individual ASI (due to its instrument errors), and not just one POH/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 a POH/AFM. Changing limiting or operational airspeeds in the FAA approved part of a POH/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 POH/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 POH/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 display 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 a POH/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 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 POH/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 a POH/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 test 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 a POH/AFM because then they are valid for all airplanes of the same type, for which the POH/AFM applies. As also mentioned above, another reason for publishing airspeeds as CAS is that the POH/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 POH/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 (§ 3.2.12 above). The airspeed instrument correction table should be mentioned in the POH/AFM, like all required placards are. With this table, and with the position error chart in the POH/AFM, the pilot can determine the Indicated Airspeed to maintain a desired Calibrated Airspeed (that is published in the POH/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, and 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 a POH/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 V_{MC} is 66 – 2 + 4 = 68 KIAS. In a POH/AFM that publishes indicated airspeeds with a zero instrument error, as GAMA recommends, the V_{MC} is published as 66 KCAS and 66 – 2 = 64 KIAS. When maintaining 64 KIAS, 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 favorable 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 (§ 3.5.20). 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 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 at a flight speed V of 80 kt have a large influence on the generated control forces. A rudder ratio changer in large airplanes reduces the rudder deflection per degree of rudder pedal travel, to avoid overloading the vertical fin, also with a quadratic function of speed with increasing airspeed, and not with a few knots.
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 and 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 correct and safe operational and limiting airspeeds, and 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 POH/AFM, and must add the position error in the POH/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.

3.4.5. 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, and 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. Manufacturers of large airplanes do so already since World War II.

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. In the Specification many more statements are found that are not in agreement with FAR 23 and FAA Flight Test Guides. The writers of the GAMA Specification No. 1 obviously had a disappointing understanding of airplane speeds, performance, and control, and of FAR 23, and did not contribute to preventing the many fatal accidents referred to in § 1.1 above. It is also incomprehensible that the FAA approved GAMA Specification No. 1 and the POH/AFMs that were prepared using the Specification. Many accidents occurred and were investigated by TSBs around the globe, but obviously none of these boards reported errors in POH/AFM and recommended or mandated improvements during the past 50 years. Aviation is drifting into failure due to incompetence of key-personnel the public relies on.
So far, the airspeed theory. In the next chapters, GAMA Specification No. 1 will be reviewed.

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.
FAR 23 defines minimum control speed as V_{MC} for the takeoff configuration which is to be

published in the POH/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 POH/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[12] 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*".

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 POH/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.

3.5.4. ***Limitations Due To the Size of the Vertical Tail***. In Figure 3 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.

[12] 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

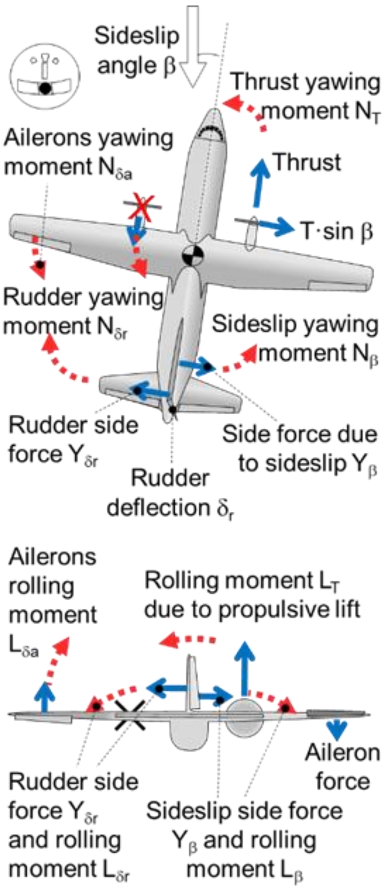

Figure 3. Lateral-Directional forces and moments in body axis coordinate system, OEI, wings level, straight flight.
Forces are not to scale.

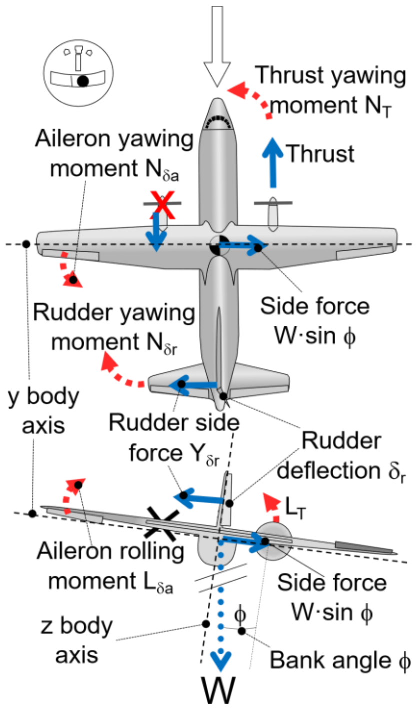

Figure 4. Lateral-Directional forces and moments in body axis coordinate system, OEI, bank angle 5° into good engine, steady straight flight.

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 4), that replaces the side force due to sideslip that was a consequence of the rudder deflection (Figure 3). 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 3), 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.

3.5.5. 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. Dr. Jan Roskam of Kansas University explains this in *Airplane Design Part VII*[2].

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.

3.5.6. ***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}*[13]. The resulting graphs presented in Figure 5 and Figure 6 below are calculated in this paper using stability derivative data of a sample 4-engine turbojet airplane, which is usually 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.

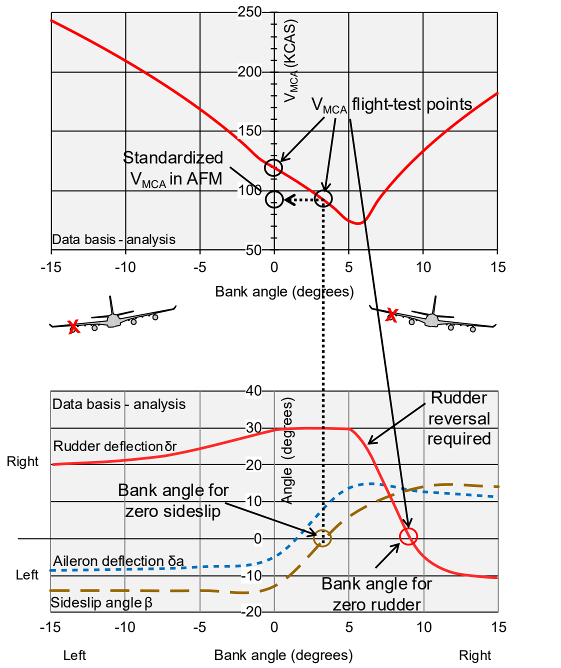

Figure 5. Effect of bank angle on V_{MCA} and on rudder, aileron, and sideslip angles during equilibrium flight at maximum thrust, for a sample airplane.

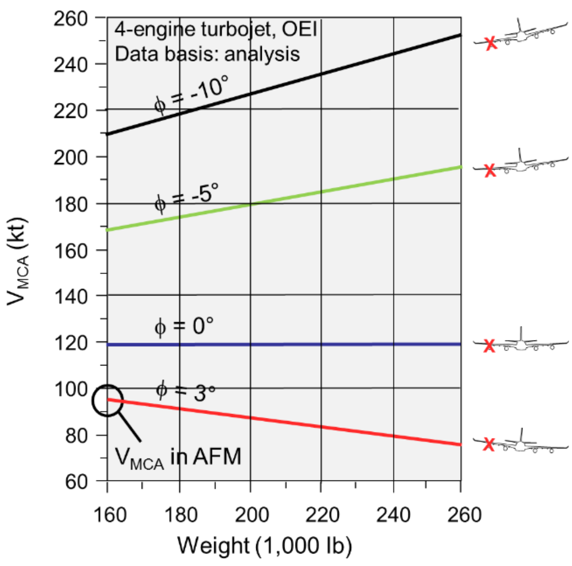

Figure 6. Effect of bank angle and weight on (actual) $V_{MC(A)}$.

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.

3.5.7. Figure 5 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.

[13] 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

3.5.8. 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 4. Figure 5 and Figure 6 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).

3.5.9. Another important observation of Figure 5 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 5. 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 favorable to the safety margin above V_{MCA}. V_{MCA} increases considerable with banking to either side to values above V_{MC} for straight flight.

3.5.10. 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 (and to accident investigators) when they need maximum thrust 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 (software) in the AFM for maintaining straight flight with a small bank angle while an engine is inoperative and the asymmetrical power setting is high. 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.

3.5.11. ***Flight-Testing To Determine V_{MC}***. 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·sin ϕ), 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}.

3.5.12. 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 3). 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 favorable bank angle is being maintained. When the bank angle for zero rudder (Figure 5) 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 5. The V_{MC} data on the left edge (lowest weight) of Figure 6 coincides with the V_{MC} data in Figure 5. A higher weight affects the actual V_{MC}. With a zero bank angle, weight has no effect (side force W·sin 0° = 0).

3.5.13. 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.

3.5.14. 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.

3.5.15. 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 POH/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.

3.5.16. ***Definition Of V_{MC} in a* POH/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 a POH/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 POH/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 POH/AFM-published V_{MC} during flight testing, which is usually between 3° and 5° away from the inoperative engine, as was illustrated in Figure 5 and Figure 6 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 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 a POH/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 a POH/AFM.

3.5.17. ***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).

3.5.18. 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 POH/AFM.

3.5.19. **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.

3.5.20. ***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.

3.5.21. The V_{MCA} data presented in Figure 5 and Figure 6 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 POH/AFM, as FAR 23.1583(a)(1) requires, not only of V_{MC} for takeoff.

3.5.22. Examples of ***controlling $V_{MC(A)}$*** and of the **significance of $V_{MC(A)}$** are included in the following abbreviated 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.

3.5.23. ***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 POH/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 POH/AFM should remind pilots with: '**Published $V_{MC(A)}$ is valid for straight flight only while maintaining a 5° bank angle into the good engine. $V_{MC(A)}$ increases during turns**', and: **'The pilot controls the actual $V_{MC(A)}$ with bank angle and (asymmetrical) level of thrust'**.

3.5.24. 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 $V_{MC(A)}$ is the lowest airspeed which can be obtained during steady straight flight while maintaining 5° bank towards the good engine, with full directional and/or lateral control inputs when one engine fails or is inoperative, and the opposite engine is set at maximum thrust.
$V_{MC(A)}$ increases with wings-level and increasing bank angles to either side and with the thrust level of the good engine and hence, is controlled by the pilot'.

3.5.25. 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 the actual V_{MCA} during turns or with the increase of the asymmetrical thrust. ICAO would call this Systemic Errors. GAMA Specification No. 1 is therefore relevant to preventing Systemic Errors as well.

3.5.26. The paper *Airplane Control and Analysis of Accidents after Engine Failure*[14], explains almost all about V_{MCA}, and analyzes a few accidents after engine failure.
Following the introductory paragraphs above, GAMA Specification No. 1 is 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.

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

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 take-off 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 § 3.2.3 above.

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

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 <u>zero instrument error</u>".*

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 (§ 3.2.11 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 by an Airspeed Indicator, and is the CAS when corrected for 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 (§ 3.2.10 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 11, page 37, and to the CAS equation in Figure 2. TAS is equal to CAS in a standard atmosphere at sea level.

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

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 § 3.5.24. 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[15], 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 § 3.5.7 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 (§ 3.5.9).

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 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 (§ 3.5.4 above), operating, or handling characteristics (from § 3.5.6 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

[15] 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.

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 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 5 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 (§ 3.5.5 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.

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.

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} (§ 3.5.11); 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} 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 ½ρV^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.

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 $\phi = 0$ 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 14.

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 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 1). When the instrument error is indeed zero, then Vic is equal to IAS, but most ASIs have an instrument error up to ± 4 kt (§ 3.2.10 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 redlined V_{MCA} of 80 KIAS and an engine fails, the airspeed is 2 kt below the actual V_{MCA}, 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[16]. And during other bank angles actual V_{MCA} increases even more (Figure 5 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.

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.

[16] 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.

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 5). 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 5 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 13 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}, 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!

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 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 (§ 3.5.22). 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)), § 3.5.23 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. 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 (§ 3.5.22). 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 (§ 3.5.25). 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 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, in compliance with FAR 23.149. The definitions of the minimum control speed and other airspeeds are inappropriate, and FAR 23 requires the instrument errors of airspeed Indicators to be furnished to the pilots. 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. 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 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 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 training, competence, and experience, i.e. the own field of vision of many people, even self-called 'professionals' or 'experts' in aviation, is not sufficiently wide to prevent fatalities. Universities and test pilot schools widen the field of vision of aviators which results in deep understanding; opinions of the incompetent don't, and require unlearning.
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)[17]. Dr. Weener regrettably did not respond to a letter from Avio*Consult*, nor did the FAA, ATSB, and many more organizations and manufacturers who were made aware. Douglas Adams obviously hit the right note. Regrettably, *"The Truth Is Not Always Welcome"* as Schopenhauer also wrote.

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. 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 (§ 3.5.23 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 (§ 3.2.12). CAS is the airspeed of the airplane in undisturbed air and as 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

[17] NTSB Most Wanted List, Presentation by Board Member Dr. Earl F. Weener https://www.youtube.com/watch?v=f78kS4Xzbis

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 14, § 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, because *"You only see what you look for and you only look for what you know"*.

ATTACHMENT

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/.

LIST OF ABBREVIATIONS AND SYMBOLS

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

SPECIFICATION FOR PILOT'S OPERATING HANDBOOK

GAMA SPECIFICATION NO. 1

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

prepared by

**General Aviation
Manufacturers Association**

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.

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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
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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.

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SECTION 0

TECHNICAL PUBLICATION GUIDANCE

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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."

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 "l" 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.

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)

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.

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

INTENTIONALLY LEFT BLANK

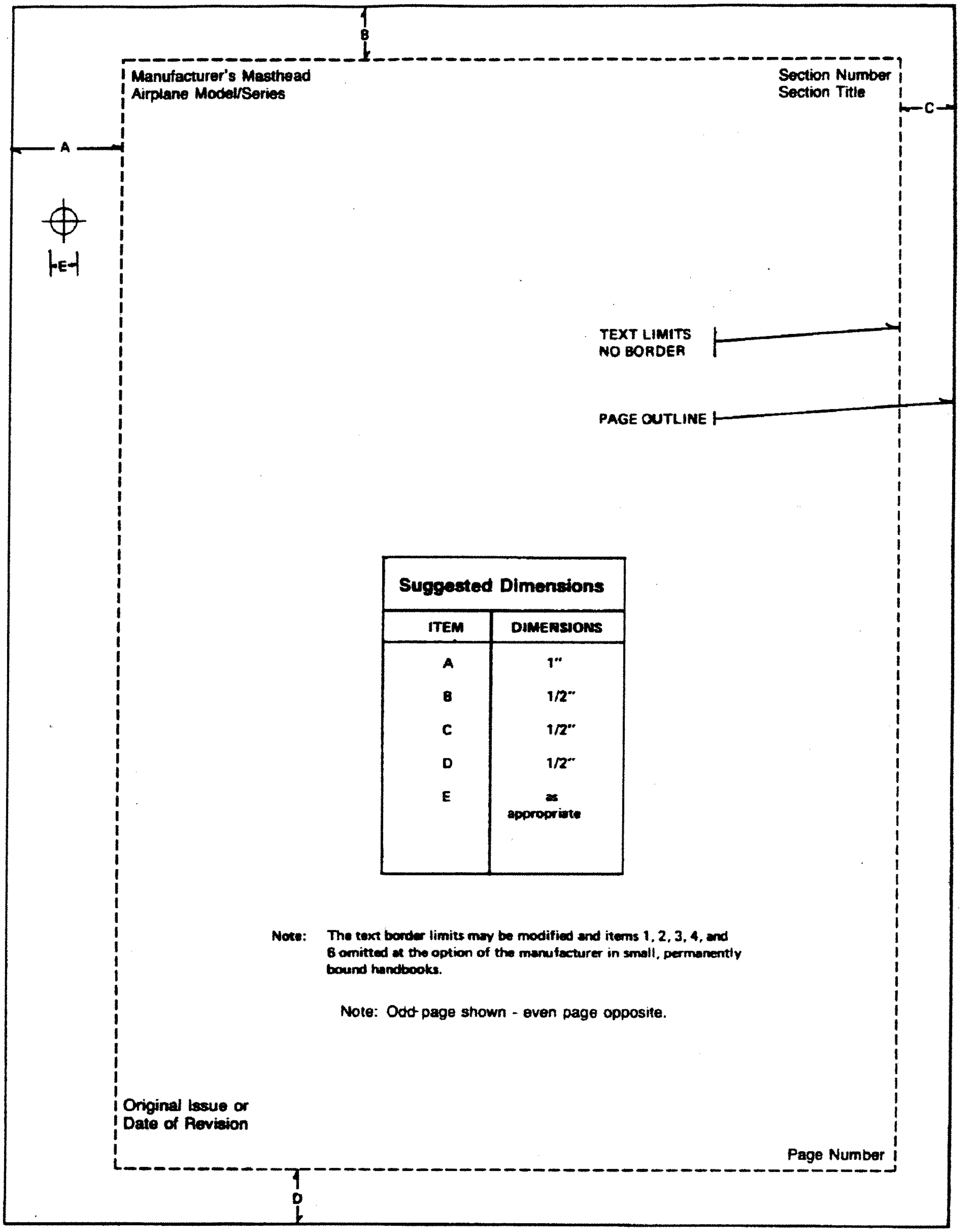


Figure 0-2
Suggested Vertical Page Layout

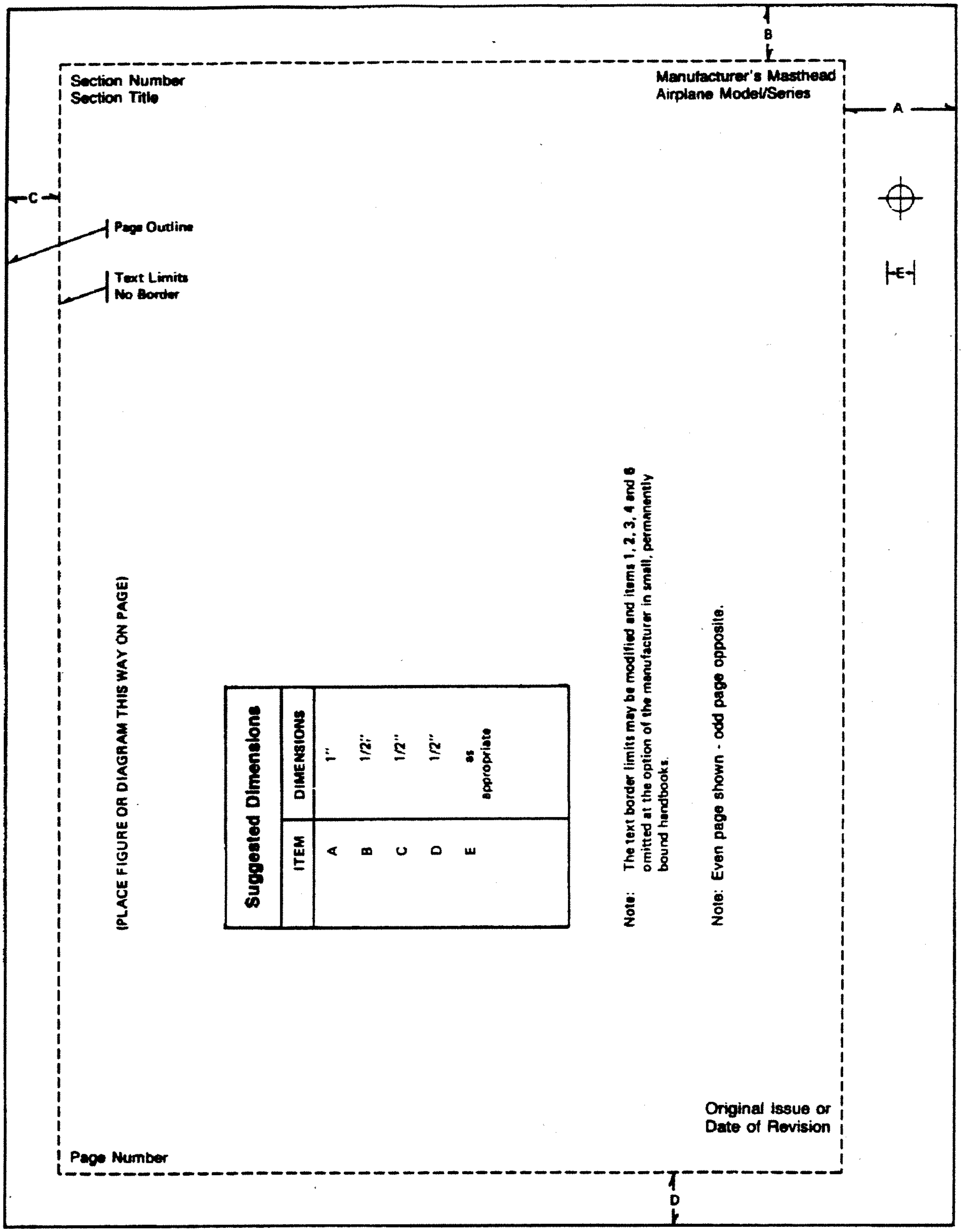


Figure 0-3
Suggested Horizontal Page Layout

Manufacturer's Masthead
Airplane Model/Series

Section Number
Section Title

PILOT'S OPERATING HANDBOOK

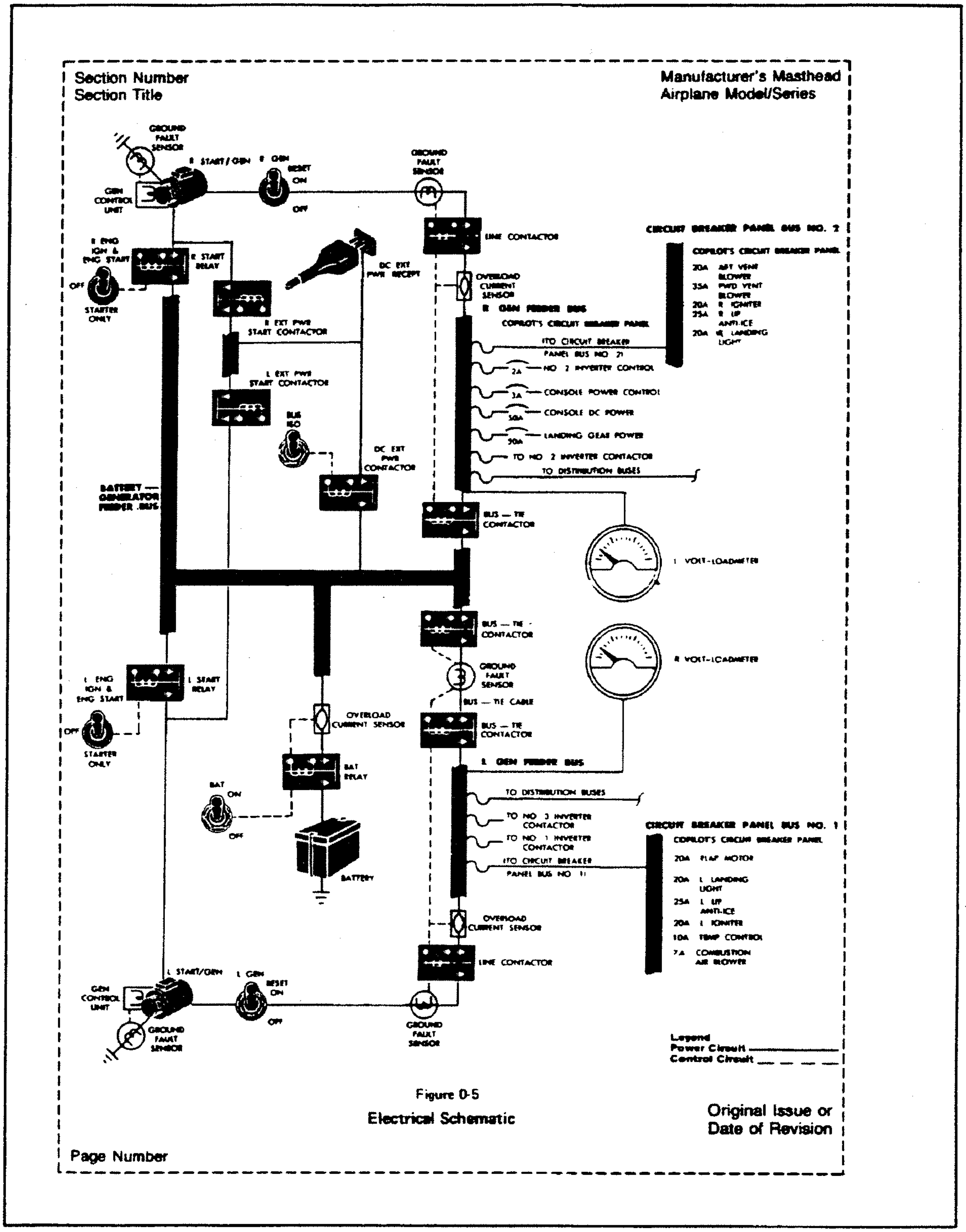
LOG OF REVISIONS

Revision Number and Date	Revised Pages	Description of Revision

Original Issue or
Date of Revision

Page Number

Figure 0-4
Suggested Log of Revisions

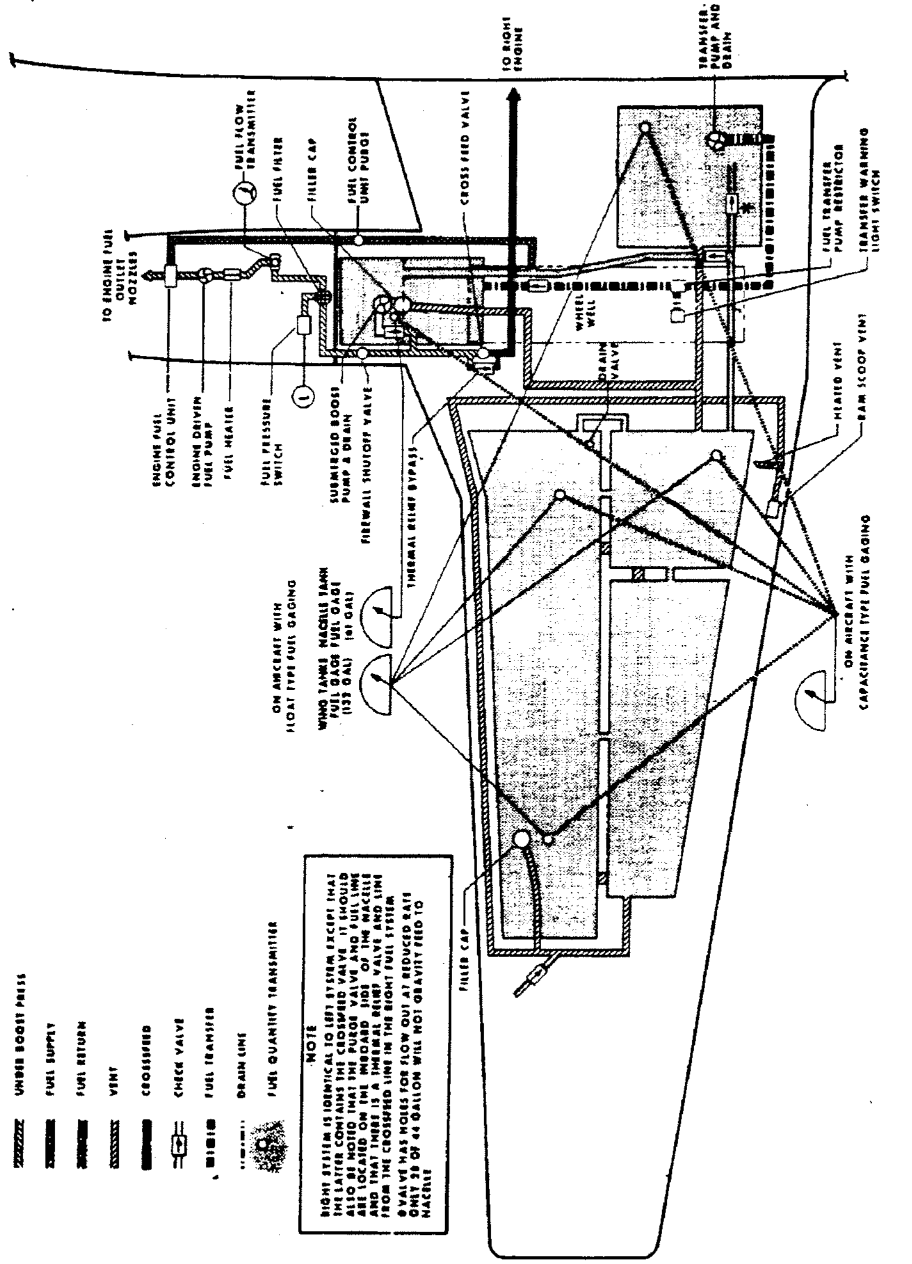


Page

Figure 0-5
Suggested Vertical Schematic

Manufacturer's Masthead
Airplane Model/Series

Section Number
Section Title



Original Issue or
Date of Revision

Figure 0-6
Fuel System Schematic

Page Number

Layout

Figure 0-6
Fuel System Schematic

SECTION 1

GENERAL

TABLE OF CONTENTS

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

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

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.

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

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.

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.

SECTION 2

LIMITATIONS

TABLE OF CONTENTS

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)

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

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

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

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

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.

SECTION 3

EMERGENCY PROCEDURES

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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 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.

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

SECTION 3A

ABNORMAL PROCEDURES

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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 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

SECTION 4

NORMAL PROCEDURES

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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 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 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.

SECTION 5

PERFORMANCE

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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

(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*

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.

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

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

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.

LIST OF FIGURES

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 4000	2410 2840	3850 4600	2720 3230	4320 5020
11,000	98	115	2000 4000	2170 2580	3450 4015	2415 2860	3800 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:

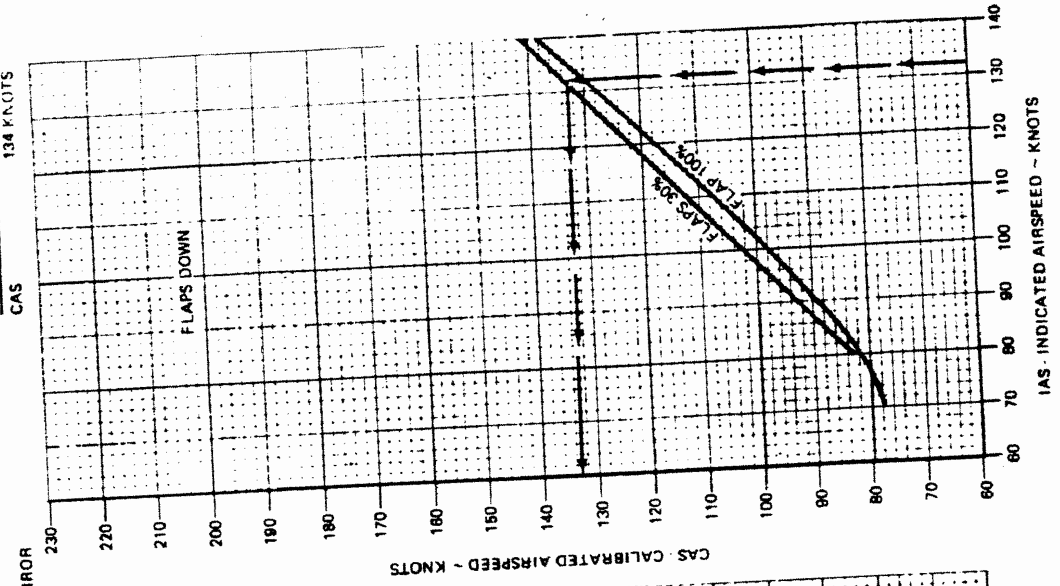
Takeoff Speeds	
Lift-off	99 KIAS
50 feet	116 KIAS
Ground Roll	2818 FEET
Total to Clear 50' Obstacle	4416 FEET

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

AIRSPEED CALIBRATION — NORMAL SYSTEM



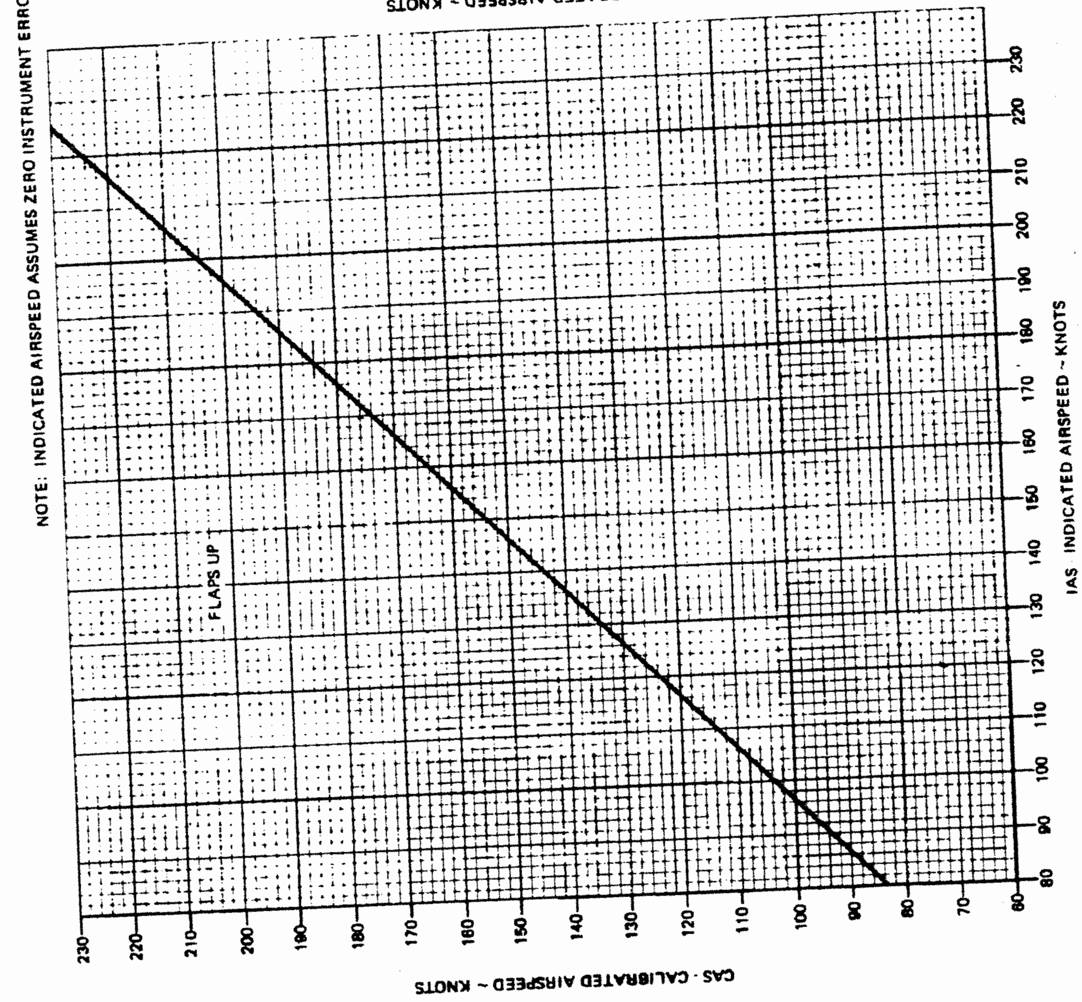


Figure 5-2

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

ALTIMETER CORRECTION — NORMAL SYSTEM

NOTE: INDICATED AIRSPEED AND INDICATED ALTITUDE ASSUME ZERO INSTRUMENT ERROR

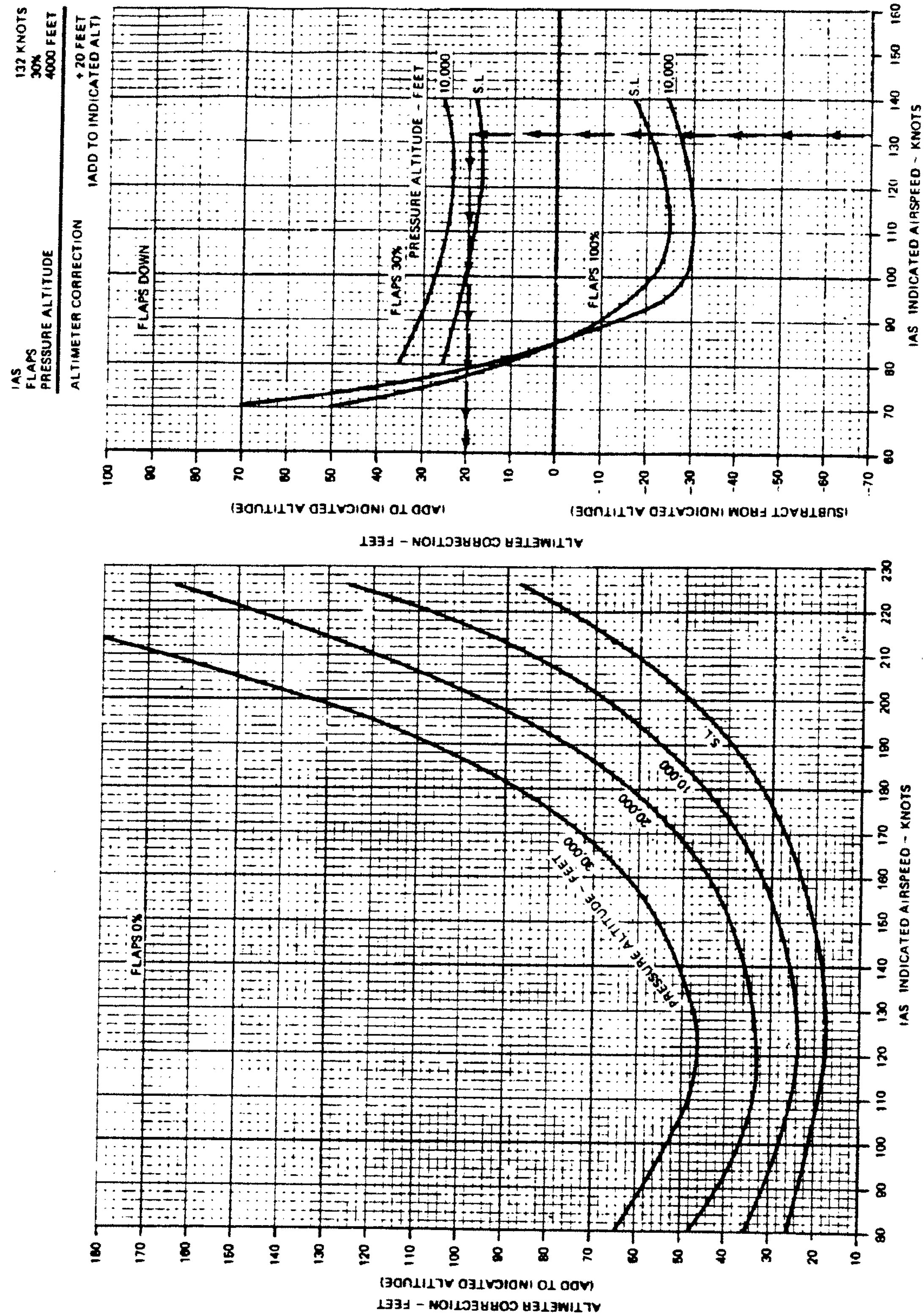


Figure 5-4

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

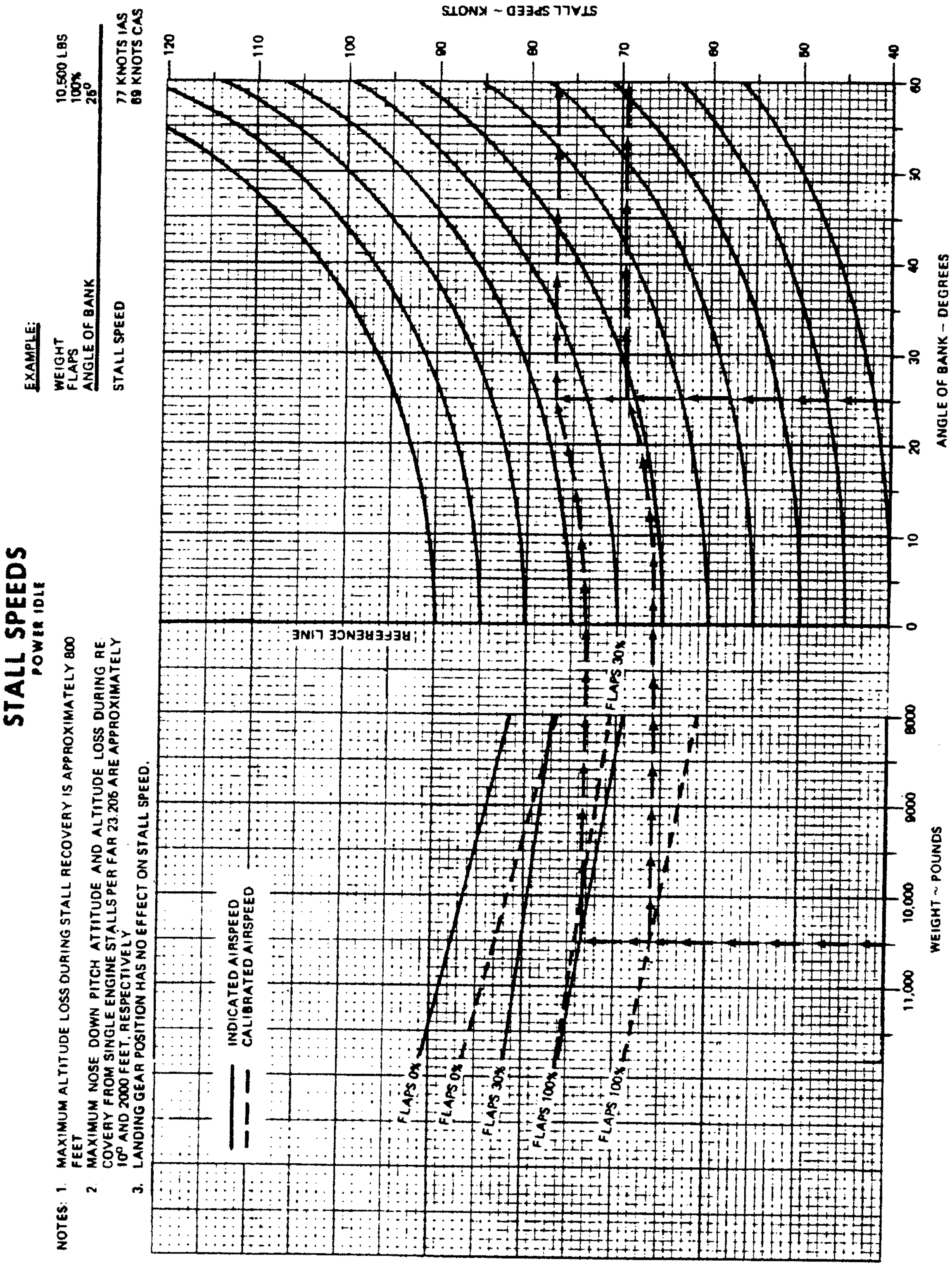


Figure 5-6

Figure 5-6

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

MAXIMUM TAKEOFF WEIGHT

OPERATING LIMITATION

EXAMPLE:

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

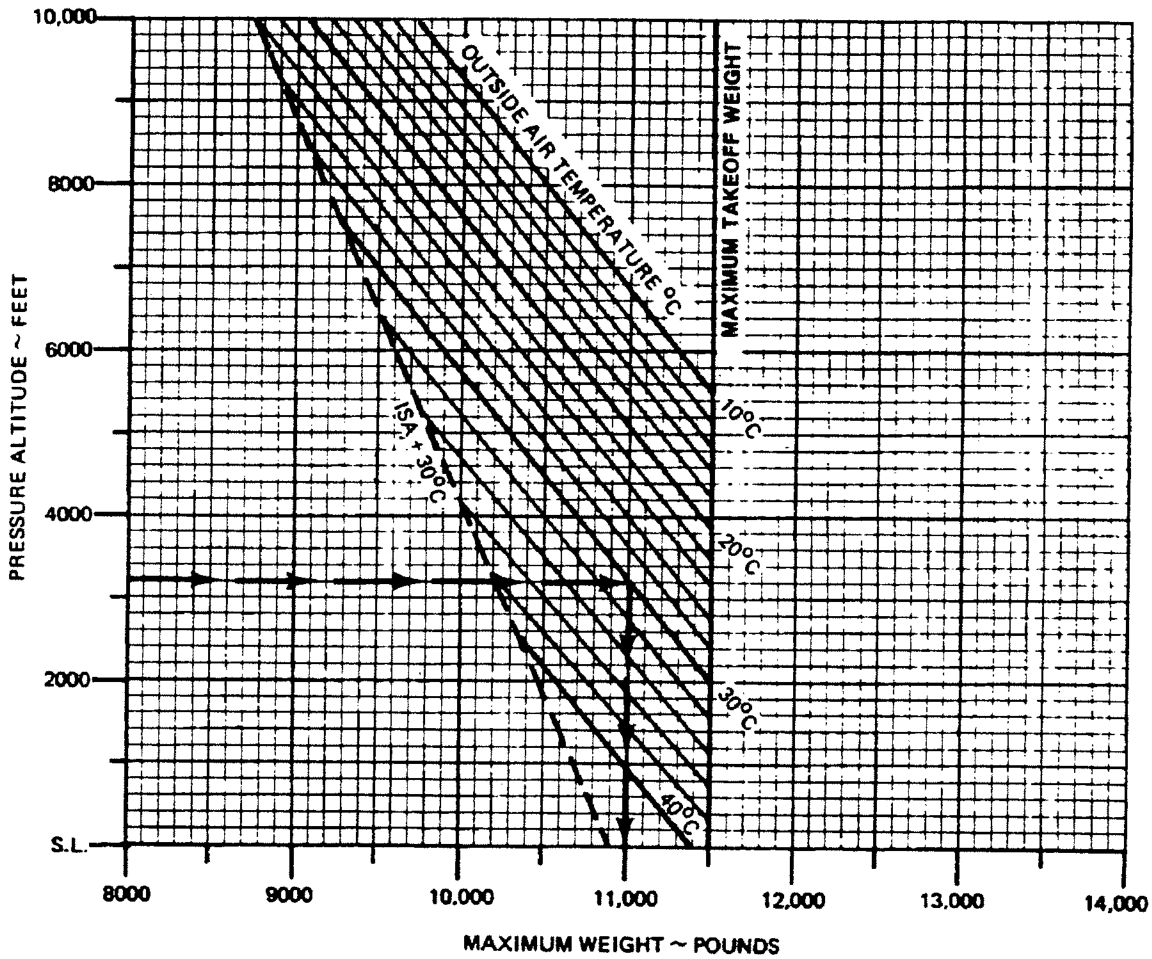


Figure 5-8

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	116
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.

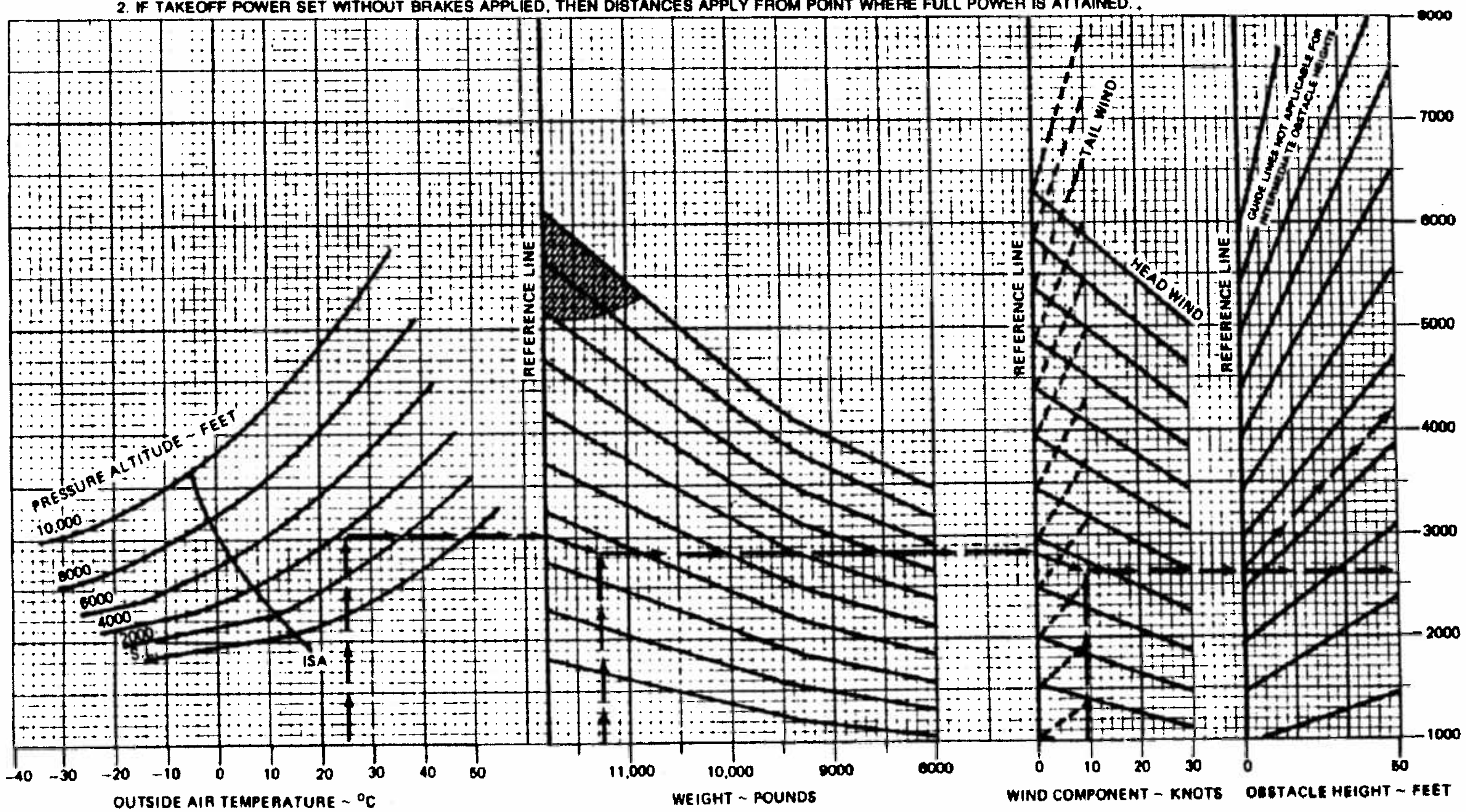


Figure 5-9

Issued: February 15, 1975
Revised: October 18, 1996

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	2860	4450	3230	5250
			6000	2400	3740	2700	4260	3030	4830	3400	5470	3900	6300
			8000	2850	4500	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

ACCELERATE — STOP DISTANCE — 0% FLAPS

ASSOCIATED CONDITIONS:

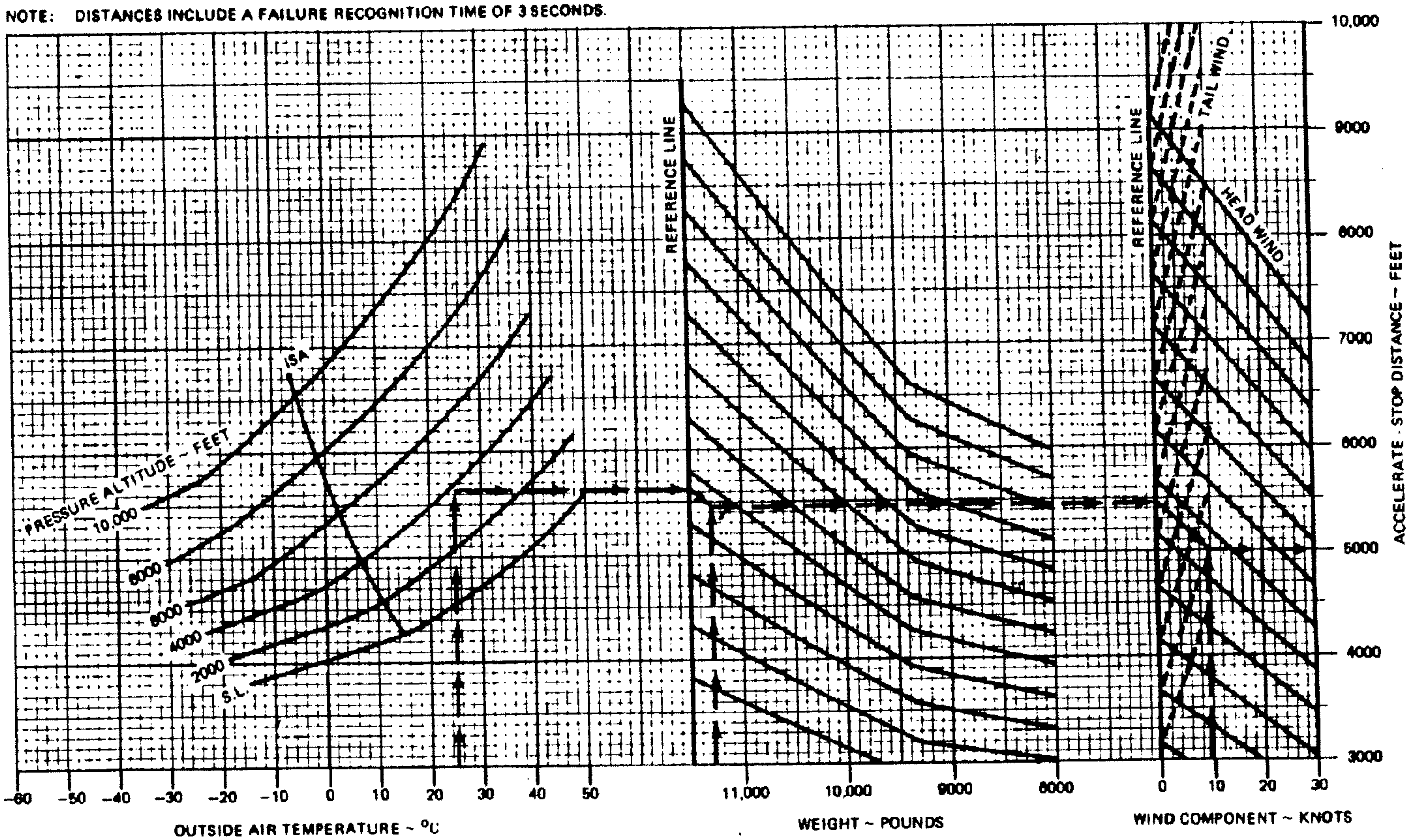
POWER	1.	TAKEOFF POWER SET BEFORE BRAKE RELEASE
	2.	BOTH ENGINES IDLE AT ENGINE FAILURE SPEED AND REVERSE OPERATING ENGINE
FLAPS		0%
BRAKING		MAXIMUM
RUNWAY		PAVED, LEVEL, DRY SURFACE

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

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

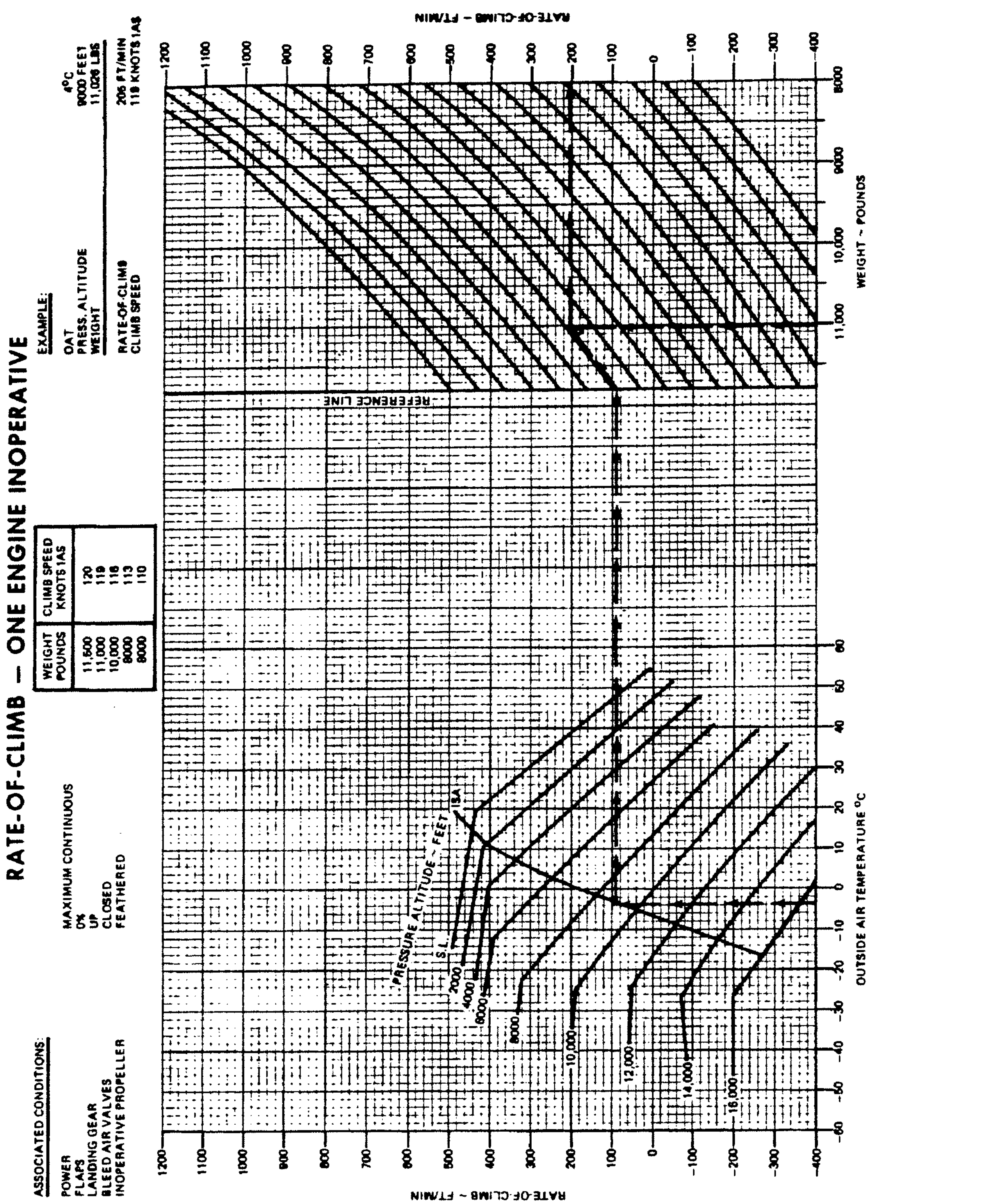
1. APPROXIMATION METHOD
   ACCELERATE-STOP DISTANCE 5870 FT
   ENGINE FAILURE SPEED 98 KIAS
2. INTERPOLATION METHOD
   ACCELERATE-STOP DISTANCE 5077 FT
   ENGINE FAILURE SPEED 98 KIAS

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



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
PRESSURE ALTITUDE ~ FEET
ISA
S.L.
2000
4000
6000
8000
10,000
12,000
14,000
16,000
REFERENCE LINE
OUTSIDE AIR TEMPERATURE °C
-60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60
WEIGHT ~ POUNDS
8000 9000 10,000 11,000
RATE-OF-CLIMB ~ FT/MIN
1200 1100 1000 900 800 700 600 500 400 300 200 100 0 -100 -200 -300 -400

Figure 5-13

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

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.

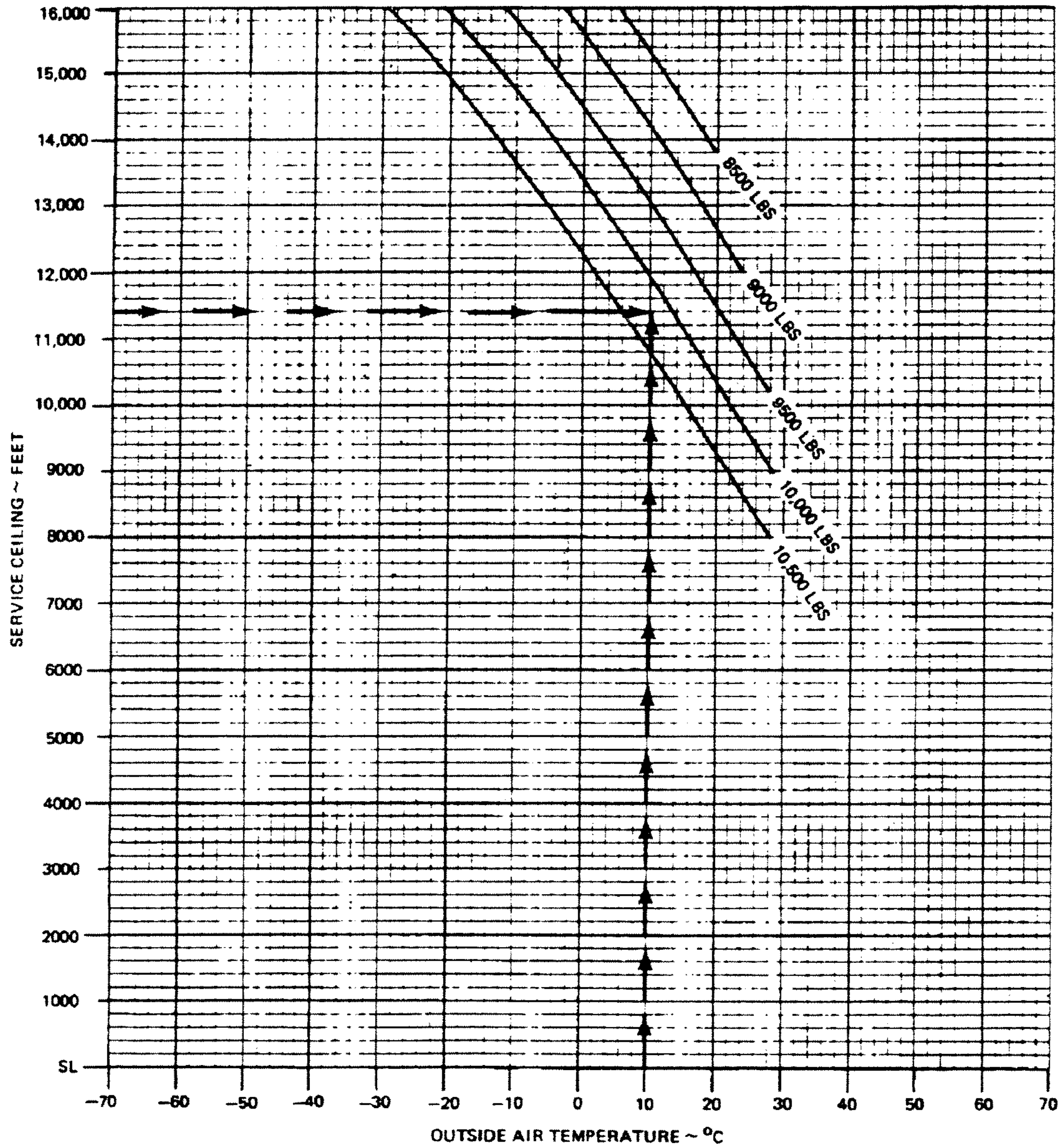


Figure 5-15

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

TIME, FUEL, AND DISTANCE TO CLIMB

WEIGHT POUNDS	CLIMB SPEED KNOTS IAS
3300	130
2800	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

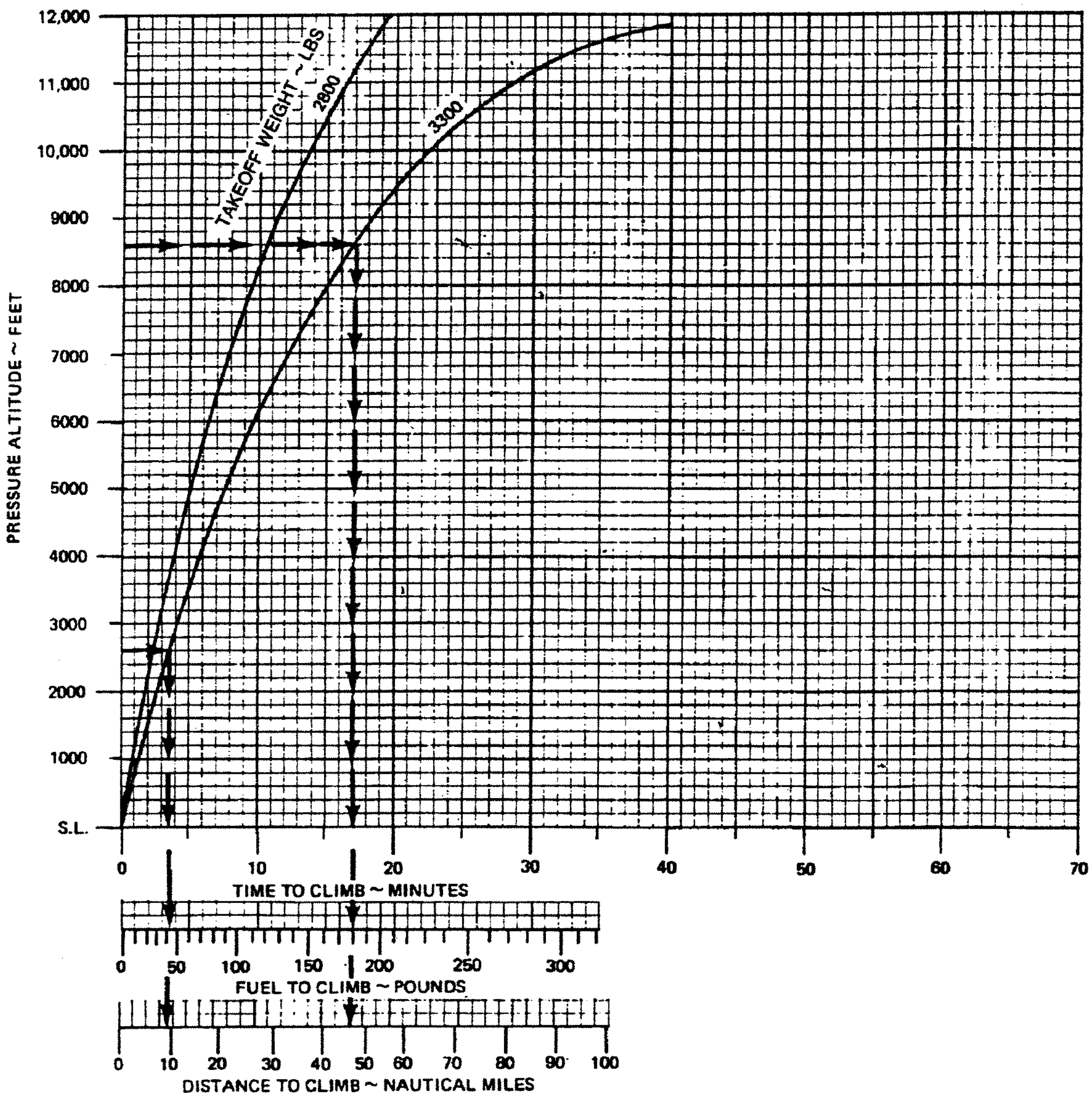


Figure 5-17

TIME, FUEL, AND DISTANCE TO CLIMB

ASSOCIATED CONDITIONS:		EXAMPLE:	
POWER	MAX. M.P. AT 2700 RPM	ALTITUDE	17,500 FT
FUEL MIXTURE	RECOMMENDED LEANING SCHEDULE	WEIGHT	3,350 LBS
FUEL DENSITY	6.0 LBS/GAL	INDICATED AIR SPEED	89 KIAS
FLAPS	0%	RATE-OF-CLIMB	765 FT/MIN
TEMPERATURE	STANDARD DAY (ISA) (SEE NOTE 2, FOR APPROX. PERFORMANCE ABOVE ISA)	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.
		3600	1030	0	12	0
SEA LEVEL	90	3100	1300	0	12	0
		2600	1660	0	12	0
		3600	950	5	30	9
5,000	90	3100	1220	4	24	7
		2600	1570	3	18	8
		3600	860	11	42	20
10,000	90	3100	1120	8	36	16
		2600	1470	6	30	12
		3600	740	18	60	35
15,000	90	3100	1000	14	31	28
		2600	1320	10	43	20
		3600	540	37	84	55
20,000	88	3100	780	20	68	40
		2600	1080	14	46	30
		3600	190	13	120	95
25,000	84	3100	330	29	92	65
		2600	630	20	63	45

Figure 5-18

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	15,000 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

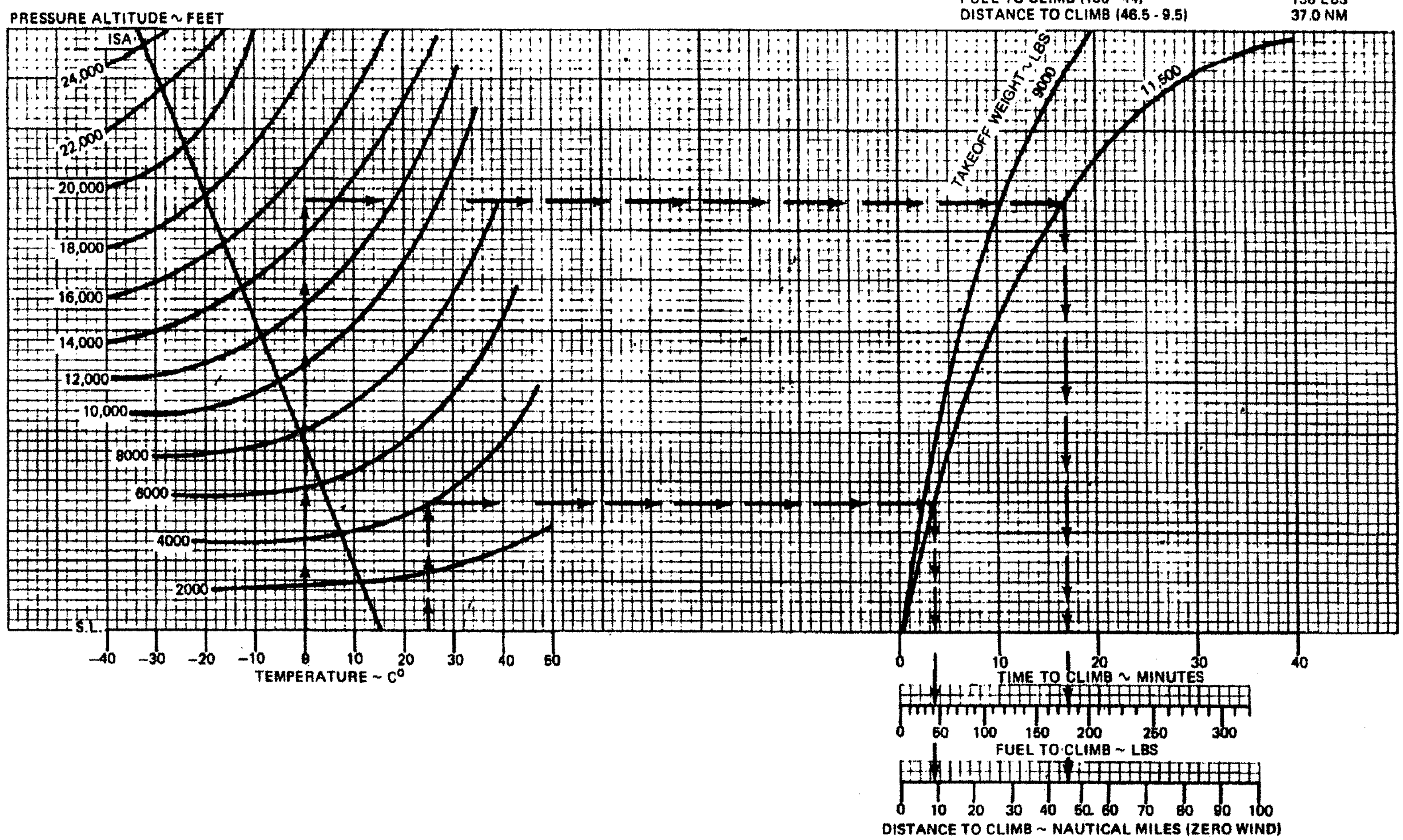


Figure 5-19

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

INTENTIONALLY LEFT BLANK

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.

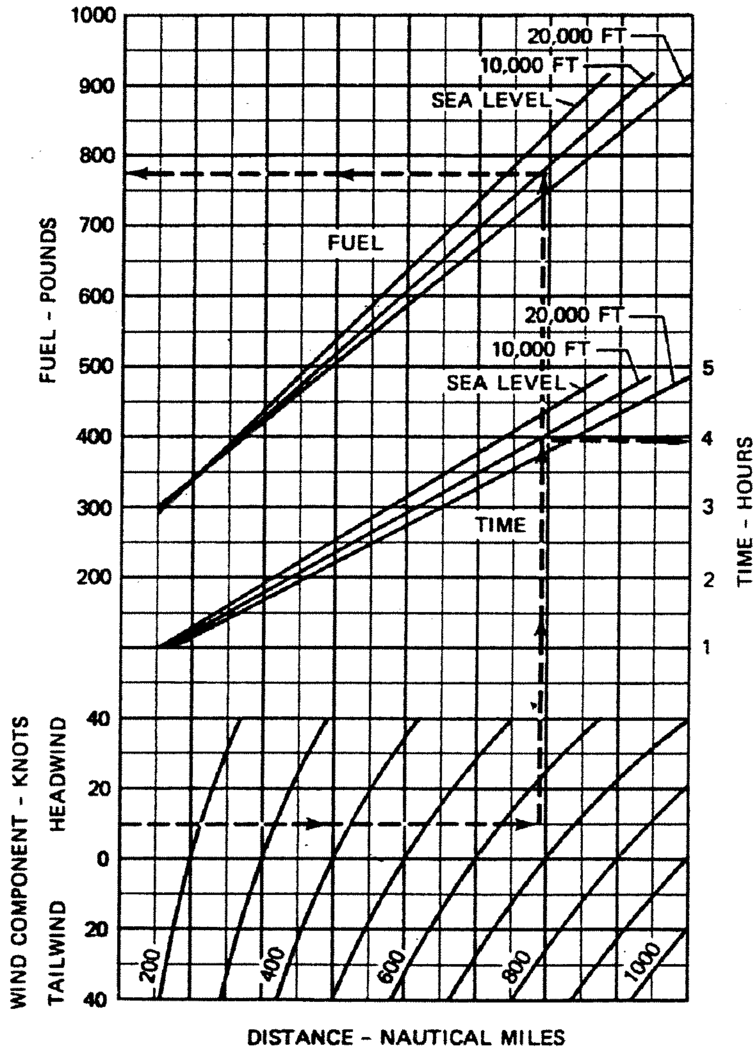


Figure 5-20A

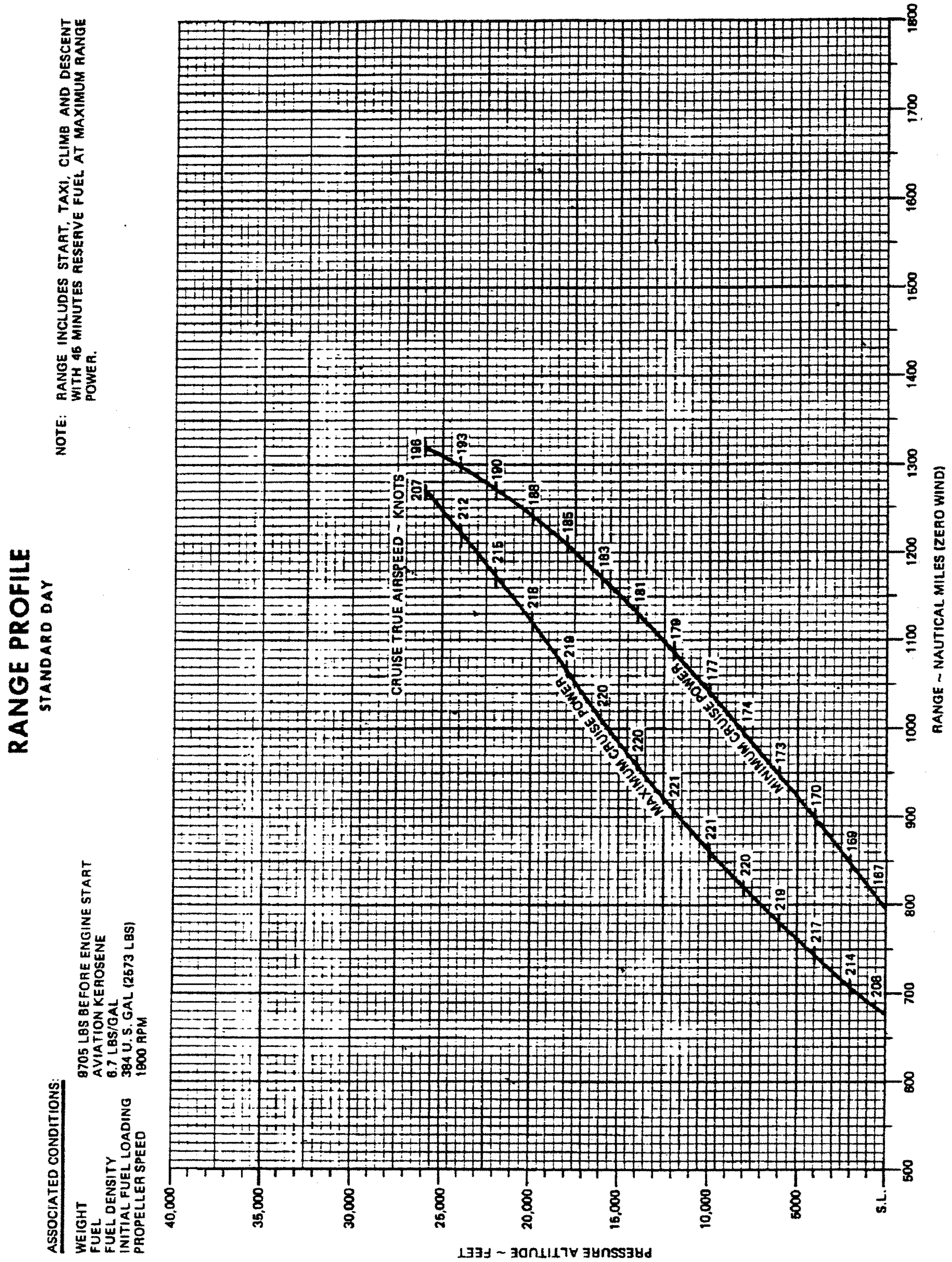

RANGE PROFILE
STANDARD DAY
NOTE: RANGE INCLUDES START, TAXI, CLIMB AND DESCENT WITH 45 MINUTES RESERVE FUEL AT MAXIMUM RANGE POWER.
ASSOCIATED CONDITIONS:
WEIGHT 9705 LBS BEFORE ENGINE START
FUEL AVIATION KEROSENE
FUEL DENSITY 6.7 LBS/GAL
INITIAL FUEL LOADING 384 U.S. GAL (2573 LBS)
PROPELLER SPEED 1900 RPM
CRUISE TRUE AIRSPEED ~ KNOTS
MAXIMUM CRUISE POWER
MINIMUM CRUISE POWER
207
212
215
218
219
220
220
221
221
220
219
217
214
208
196
193
190
188
185
183
181
179
177
174
173
170
169
167
PRESSURE ALTITUDE ~ FEET
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5000
S.L.
RANGE ~ NAUTICAL MILES (ZERO WIND)
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800

Figure 5-21

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

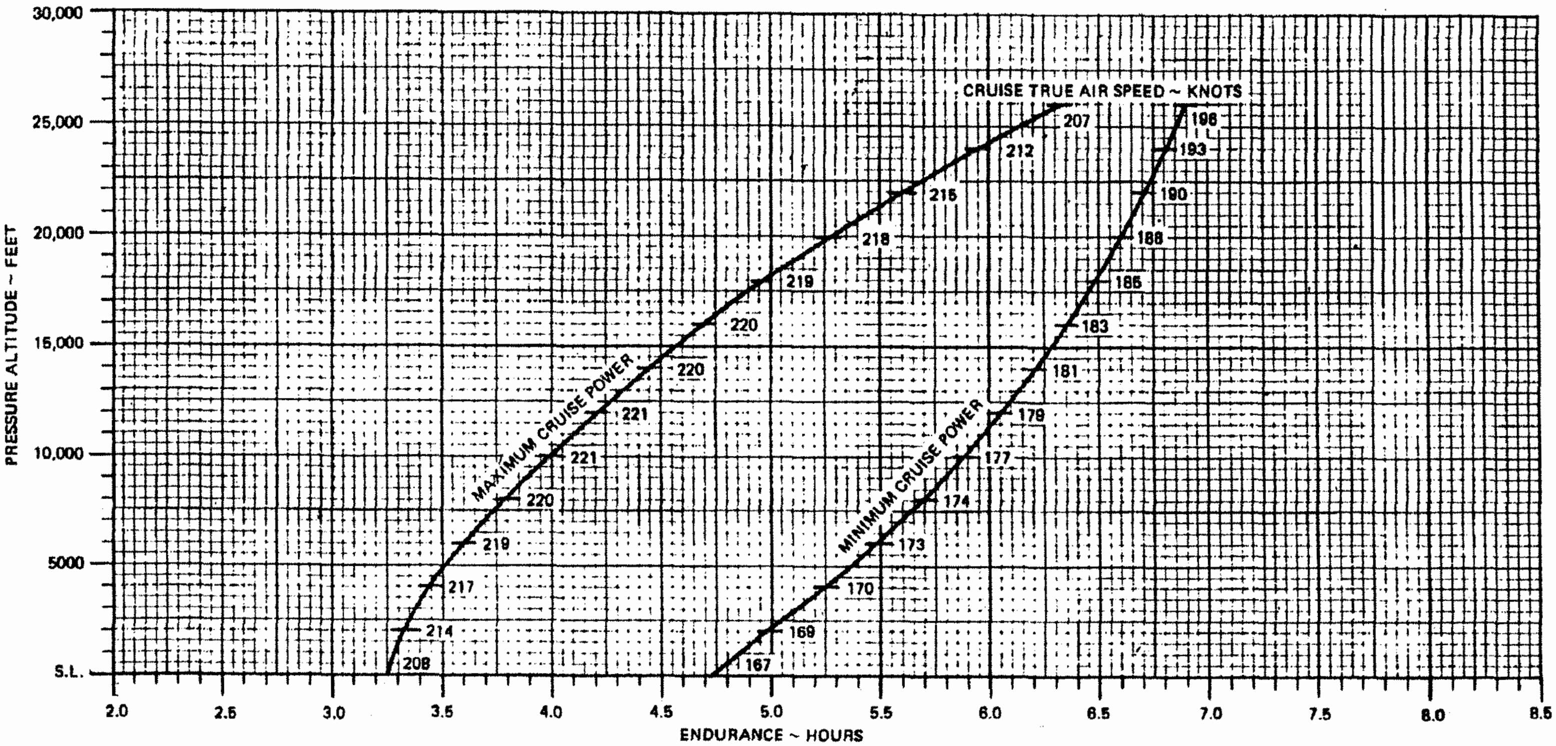


Figure 5-22

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

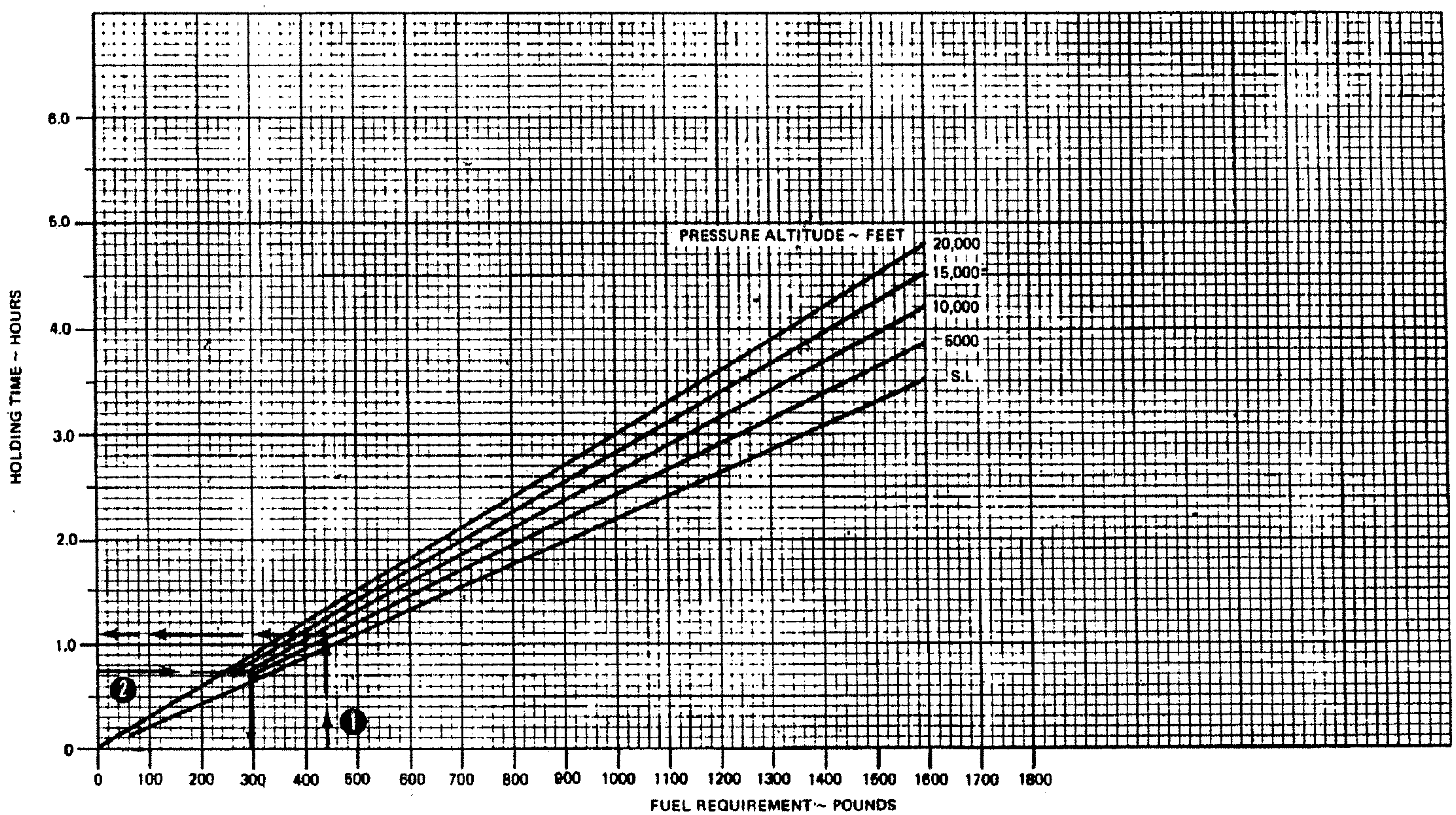


Figure 5-23

Issued: February 15, 1975
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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

TIME, FUEL, AND DISTANCE TO DESCEND

ALTITUDE ~ FEET	DESCENT SPEED KNOTS IAS
31,000 TO 20,000	160
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

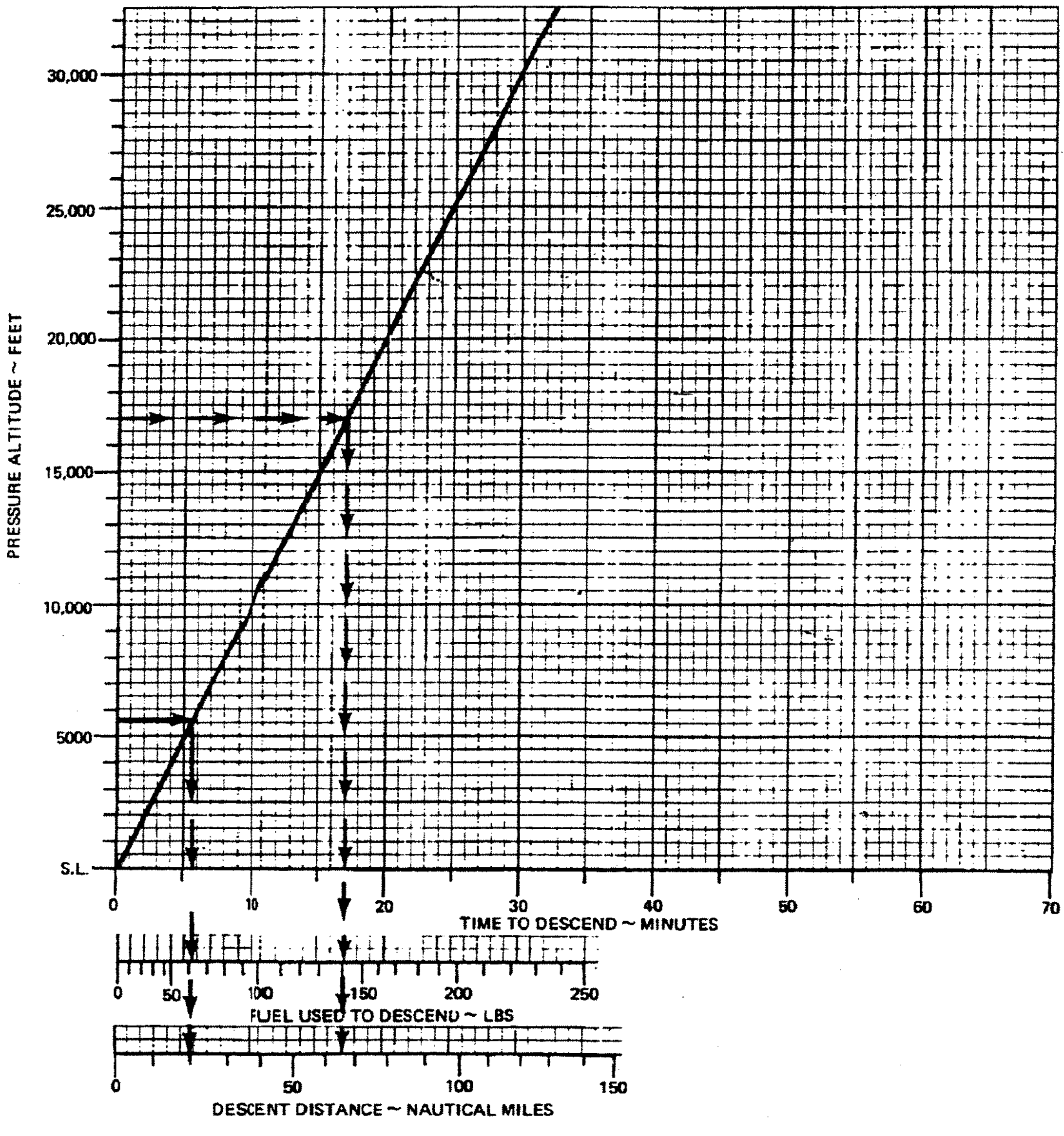

Figure 5-25

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

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

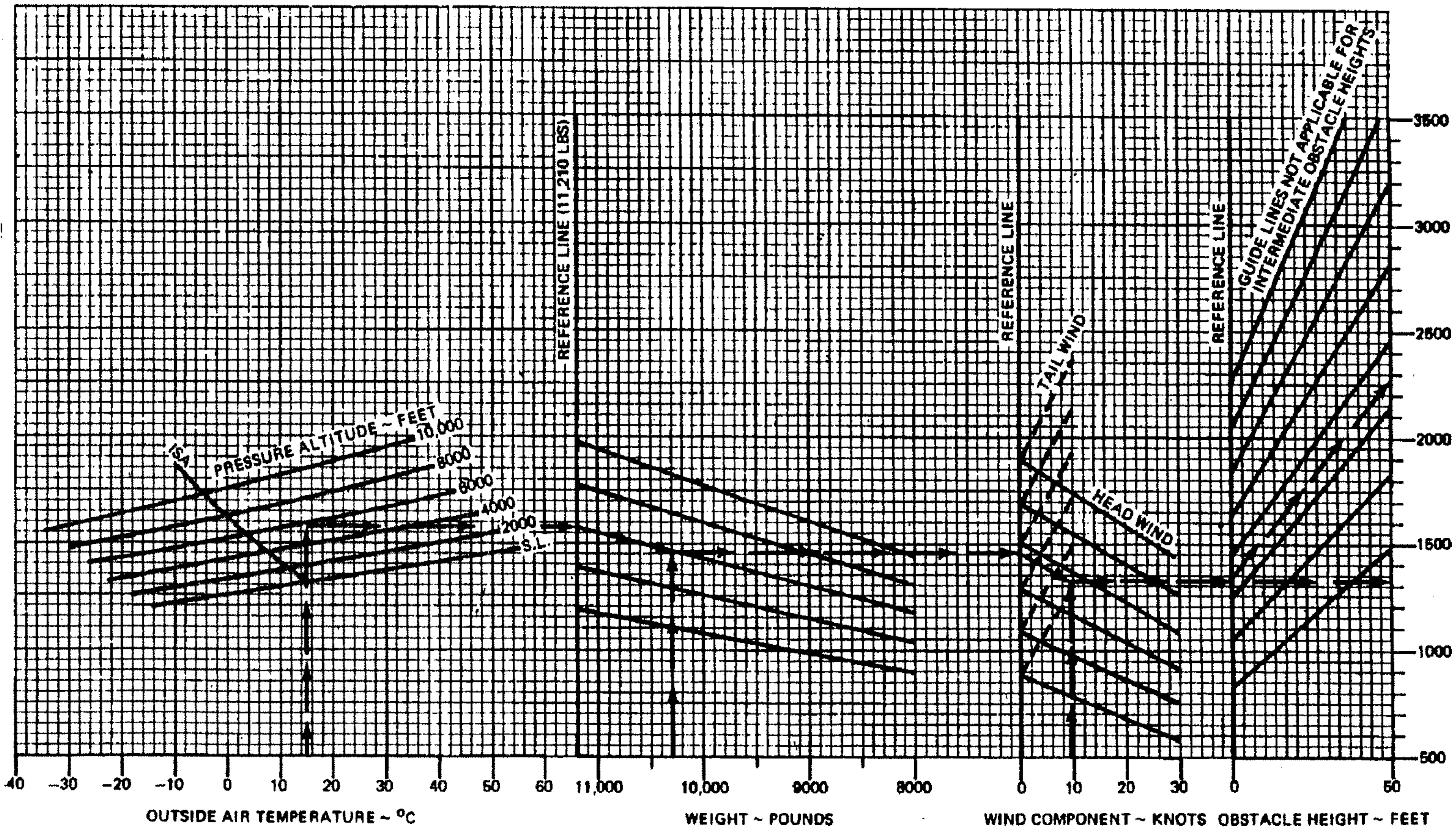

Figure 5-27

Issued: February 15, 1975
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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 GROUND ROLL	0°C TOTAL TO CLEAR 50 FT OBS	10°C GROUND ROLL	10°C TOTAL TO CLEAR 50 FT OBS	20°C GROUND ROLL	20°C TOTAL TO CLEAR 50 FT OBS	30°C GROUND ROLL	30°C TOTAL TO CLEAR 50 FT OBS	40°C GROUND ROLL	40°C 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

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

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

SECTION 6

WEIGHT AND BALANCE AND EQUIPMENT LIST (as applicable)

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SECTION 6

WEIGHT AND BALANCE AND EQUIPMENT LIST (as applicable)

6.1 General

This Section of the Pilot's Operating Handbook shall contain all weight and balance information required by the Federal Aviation Regulations and this Specification. Additional weight and balance and related information may be provided. The figures in this Section of the Specification are for illustrative purposes only. The manufacturer should use formats appropriate to the specific airplane and Handbook size.

6.3 Airplane Weighing Procedure

This paragraph describes the procedure for establishing weight and moment (relative to reference datum) of the empty airplane. Each Handbook shall have an "Airplane Weighing Form" that includes an airplane side view showing the location of weighing points (using jacking points or undercarriage) relative to the datum line. The form shall include tables for recording and correcting weighing data, and for establishing "basic empty weight" and moment. (See Figure 6-1) The calculation procedures and "basic empty weight" data used in loading calculations shall be explained.

6.5 Weight and Balance Record

Each Handbook shall contain a weight and balance record. The record shall start with the "as delivered" weight and balance data. Explain how to maintain this record when changes to the weight or moments of the airplane are made so that accurate starting data is available to calculate the weight and c. g. during normal operation of the airplane. (See Figure 6-2)

6.7 Weight and Balance Determination for Flight

This paragraph describes the procedures to calculate weight and moment for various phases of a planned flight and to ensure that the center of gravity is within approved limits.

A Weight and Moment Limit diagram shall be used to describe the c. g. limits. (See Figure 6-3)

A weight and balance loading form and an explanation of the calculation procedure shall be provided (See Figures 6-4 and 6-5 for examples). Provide weight and moment values for normal items of a load. (See Figure 6-6)

Instead of (or in addition to) the weight and balance loading form, the manufacturer may provide a device to be used to calculate weight and balance. Instructions for its use shall be provided.

6.9 Equipment List

The manufacturer shall provide an equipment list in this Section, in a separate document appended to the Handbook, or as a separate document. If the equipment list is not contained in this Section, state its location. In addition, this Section may contain a comprehensive list of equipment available for installation by the manufacturer.

The equipment list shall contain all required or optional equipment installed in the particular airplane when delivered. The list may be a suitable notation in a comprehensive list of available equipment. Equipment without significant effect on the weight or balance of the airplane need not be listed.

Describe each equipment list item and show its weight and airplane location, with respect to the datum. The weight and arm for optional equipment may be shown as the net difference between standard and optional equipment, if noted accordingly. All parts of an integral installation may be combined into a single equipment list item if variation of weight or arm is not significant. (See Figure 6-7.)

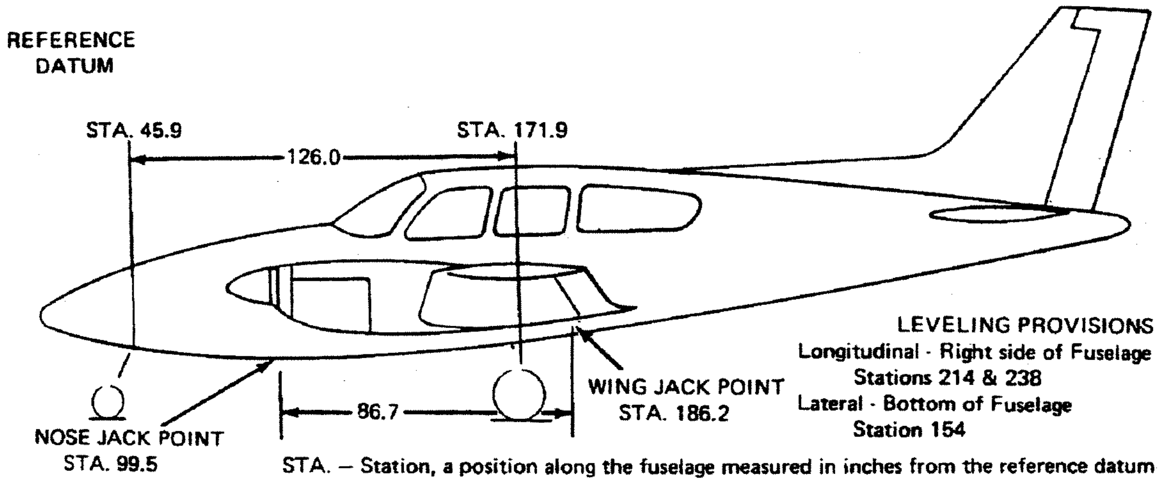
Equipment list items may be identified by an item number and may be grouped logically, using headings such as "Propeller and Propeller Accessories", "Engine and Engine Accessories", "Landing Gear", "Electrical Equipment", "Interior Equipment", "Autopilot", etc. If the equipment list is a comprehensive list of equipment available for installation by the manufacturer, a check (√) or "X" may be used to indicate the items installed when the Handbook for the specific airplane was prepared and placed in the airplane. A manufacturer may use an "X" to indicate standard or required equipment and a check (√) to indicate installed optional equipment.

Alternates for equipment may be listed under the same item number. (See Figure 6-7, Item 62) For installations made up of a number of units which may be located at various places in the airplane, each unit should be listed separately. (See Figure 6-7, Item 402)

AIRPLANE WEIGHING FORM

MODEL XXX

SERIAL NUMBER ____________ REGISTRATION NUMBER ____________ DATE ________



AIRPLANE AS WEIGHED

(Including full oil and operating fluids but no usable fuel*)

POSITION	SCALE READING	SCALE ERROR	NET WEIGHT
Left Wing			
Right Wing			
Nose			
AIRPLANE TOTAL AS WEIGHED (W)			

C G arm of airplane as weighed.

$171.9 - \frac{(126.0)W_n}{W}$ = inches aft of reference datum

or $186.2 - \frac{(86.7)W_n}{W}$ = inches aft of reference datum

BASIC EMPTY WEIGHT AND C G

ITEM		WEIGHT (LBS)	C G ARM (IN.)	MOMENT (LBS - IN.)
Subtract - Usable Fuel (if applicable)				
Add - Drainable Unusable Fuel (if weighed with fuel drained) (6 lbs per gallon)				
Optional Equipment (if applicable)				
BASIC EMPTY WEIGHT				

*Note: Normally weighed at factory without usable fuel.

Figure 6-1

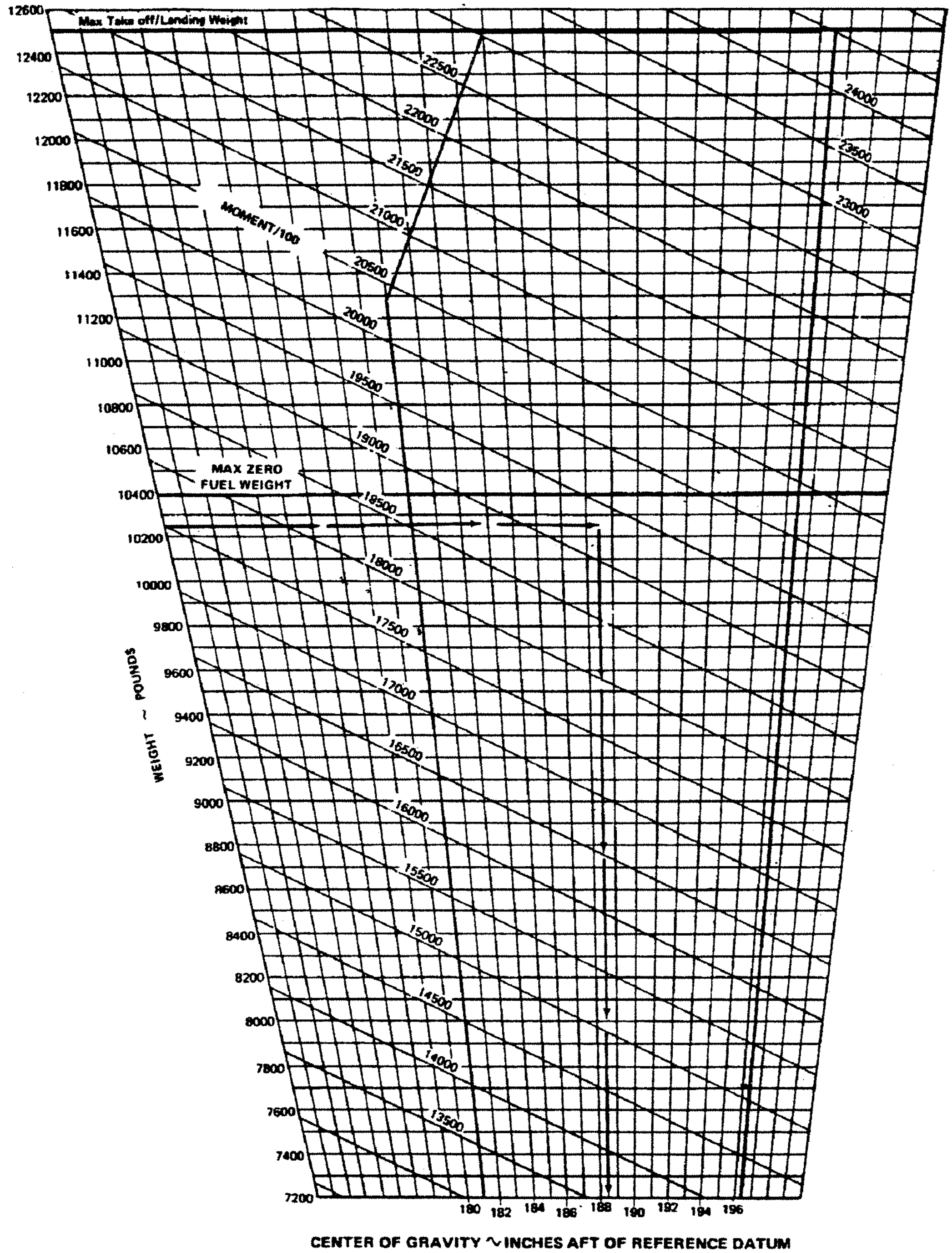
WEIGHT AND BALANCE RECORD

(Continuous History of Changes in Structure or Equipment Affecting Weight and Balance)

AIRPLANE MODEL				SERIAL NUMBER					PAGE NUMBER		
DATE	ITEM NO.		DESCRIPTION OF ARTICLE OR MODIFICATION	WEIGHT CHANGE						RUNNING BASIC EMPTY WEIGHT	
				ADDED (+)			REMOVED (-)				
	In	Out		Wt. (lb.)	Arm (In.)	Moment /100	Wt. (lb.)	Arm (In.)	Moment /100	Wt. (lb.)	Moment /100
			AS DELIVERED								

Figure 6-2

WEIGHT AND MOMENT LIMITS



EXAMPLE

AT 10,250 LBS AND 19,300 MOMENT/100
CG LOCATION IS 188.5 IN. AFT OF REFERENCE DATUM

Figure 6-3

WEIGHT AND BALANCE LOADING FORM

	WEIGHT	MOMENT (IN. LBS)
Basic Empty Weight		
Front Seats		
Middle Seats		
Rear Seats		
Fwd Luggage		
Rear Luggage		
Main Wing Tank Fuel (Usable)		
Aux Wing Tank Fuel (Usable)		
Other		
Totals		

Totals must be within approved weight and C G limits. It is the responsibility of the airplane owner and the pilot to insure that the airplane is loaded properly. The Basic Empty Weight C G is noted on the Airplane Weighing Form. If the airplane has been altered, refer to the Weight and Balance Record for this information.

Figure 6-4

WEIGHT AND BALANCE LOADING FORM

SERIAL NO.	REGISTRATION NO.	DATE

PAYLOAD COMPUTATIONS			
ITEM OCCUPANTS OR CARGO	ARM	WEIGHT	MOM/100
BAGGAGE			
CABINET CONTENTS			
TOTAL PAYLOAD			

*Totals must be within approved weight and C G limits. It is the responsibility of the airplane owner and the pilot to insure that the airplane is loaded properly. The Basic Empty Weight C G is noted on the Airplane Weighing Form. If the airplane has been altered, refer to the Weight and Balance Record for this information.

REF	ITEM	WEIGHT	MOM/100
1.	BASIC EMPTY WEIGHT		
2.	PAYLOAD		
3.	WEIGHT (LESS FUEL) (sub-total) (Do not exceed max. zero fuel weight)		
4.	MAIN WING TANK FUEL LOADING		
5.	AUX. WING TANK FUEL LOADING		
* 6.	RAMP CONDITION (Sub-total)		
7.	LESS FUEL FOR START & TAXI		
* 8.	TAKEOFF CONDITION		
9.	LESS FUEL TO DESTINATION		
* 10.	LANDING WEIGHT		

Figure 6-5

OCCUPANTS

WEIGHT	PILOT OR COPILOT ARM 65	CENTER SEATS FWD POSITION ARM 121	CENTER SEATS AFT POSITION ARM 136	5TH & 6TH SEATS ARM 150
	MOMENT/100			
120	102	145	163	160
130	111	157	177	195
140	118	168	190	210
150	128	182	204	225
160	135	194	218	240
170	145	206	231	255
180	153	218	245	270
190	167	230	258	285
200	170	242	272	300

FUEL

GALLONS	WEIGHT	MAIN WING TANKS ARM 75	AUX WING TANKS ARM 93
		MOMENT/100	
5	30	23	28
10	60	45	56
15	90	68	84
20	120	90	112
25	150	113	140
30	180	135	167
34	204	153	190
35	210	168	195
40	240	180	223
45	270	203	251
50	300	225	270
55	330	248	307
60	360	270	336
65	372	279	346
70	420	315	
75	450	338	
80	480	360	

BAGGAGE / CARGO

WEIGHT	BAGGAGE FORWARD ARM 31	BAGGAGE REAR FS 131 TO 170 ARM 150	BAGGAGE REAR FS 170 TO 190 ARM 180	CARGO FWD. OF SPAR (CENTER SEATS REMOVED) ARM 108	CARGO AFT OF SPAR (CENTER & AFT SEATS REMOVED) ARM 145
	MOMENT/100				
10	3	15	18	11	15
20	6	30	36	22	29
30	9	45	54	32	44
40	12	60	72	43	58
50	16	75	90	54	73
60	18	90	108	65	87
70	22	105	126	76	102
80	25	120	144	86	116
90	28	135	162	97	131
100	31	150	180	108	145
110	34	165	198	119	160
120	37	180	216	130	174
130	40	195		140	189
140	43	210		151	203
150	47	225		162	218
160	59	240		173	232
170	53	255		184	247
180	56	270		194	261
190	59	285		205	276
200	62	300		216	290
210	65	315			305
220	68	330			319
230	71	345			334
240	74	360			348
250	78	375			363
260	81	300			377
270	84	405			392
280	87	420			406
290	90	435			421
300	93	450			435
310		465			450
320		480			464
330		495			479
340		510			493
350		525			508
360		540			522
370		555			537
380		570			551
390		589			566
400		600			580

Figure 6-6

Issued: February 15, 1975
Revised: October 18, 1996

Format of Equipment List:

EQUIPMENT LIST

________________ Manufacturer   ______________ Model

SERIAL NO.____________REGISTRATION NO.____________________DATE:__________

ITEM NO.	ITEM	MARK IF INSTALLED	WEIGHT (POUNDS)	ARM (INCHES)
62	a. Airspeed Indicator No. 41507-6		.7	96
	b. Airspeed Indicator No. 41507-5	√	.6	96
402	Autopilot,			
	Gyro	√	15	90
	Amplifier	√	2	90
	Servo	√	5	80

Figure 6-7

SECTION 7

DESCRIPTION OF THE AIRPLANE AND ITS SYSTEMS

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SECTION 7

DESCRIPTION OF THE AIRPLANE AND ITS SYSTEMS

7.1 General

This Section of the Pilot's Operating Handbook shall describe the airplane in a manner considered by the manufacturer to be most informative to the kind of pilot considered most likely to operate the airplane. The paragraph order and detail in this Section need not be followed in a Handbook. The purpose of this Section is to provide a comprehensive guide and check list of items to be considered in the Handbook prepared by the manufacturer. This format may, of course, be used in its entirety or in part.

Generally, in describing the airplane or its system, third person wording should be used. (For example: The nose wheel is provided with a shimmy damper to keep the wheel from shimmying while rolling on the ground.) Nomenclature and terminology should be consistent. Terms which are not well known should be defined. Standard abbreviations listed in Section 1 are acceptable.

Reference to other books or to other sections of the manual should be kept to a minimum.

Where applicable the following topics should be included:

Airframe
Flight controls
Ground control
Wing flaps, dive brakes and spoiler systems
Landing gear
Baggage compartments
Airplane tie-down provisions and jack points
Seats, seat belts, and shoulder harnesses
Doors, windows, and exits
Control locks
Engine
Propeller
Fuel system
Hydraulic system
Brake system
Power steering system
Electrical system
Lighting
Auxiliary power unit
Heating, ventilating, defrosting and air conditioning systems
Cabin pressurization system
Oxygen system
Instrument panel
Pitot pressure system
Static pressure system
Vacuum or pneumatic system
Flight instruments
Autopilot, flight director, and automatic devices in the control system
Stall warning or angle-of-attack system
Icing equipment
Avionics
Comfort features
Cabin features
Windshield wipers

7.3 Airframe

(a) Describe structure of fuselage, wings, and empennage.
(b) Describe seating arrangements available.

7.5 Flight Controls

(a) Describe control surfaces.
(b) Describe operating mechanism-sketches may be provided.
(c) Explain trimming arrangements.
(d) Explain any interconnect arrangement.
(e) If controls are boosted explain the systems.

7.7 Instrument Panel

(a) Provide a drawing or picture of the instrument panel.
(b) Name and explain the use of the instruments, lights, switches and controls found on the panel.
(c) If an annunciator panel is installed, explain how it operates.

7.9 Flight Instruments

(a) Briefly describe and explain principle of operation of any new kinds of flight instruments.
(b) Explain how to check them for proper operation and how to recognize a malfunction.

7.11 Ground Control

(a) Describe how the pilot mechanically controls nose wheel or tail wheel.

(b) Describe minimum radius of turn for taxiing and ground handling.

7.13 Wing Flaps, Dive Brake or Spoiler Systems

(a) Describe aerodynamic surfaces.
(b) Explain how they are operated.
(c) Describe how application of these affects pitch attitude, airspeed, trim, and stall speed.
(d) Explain what provisions are made to prevent asymmetric conditions.

7.15 Landing Gear

(a) Describe construction.
(b) Describe retraction mechanism if provided.
(c) Describe shock absorption system.
(d) Describe wheel brakes.
(e) Explain emergency extension system.
(f) Explain how warning system functions.

7.17 Baggage Compartments

(a) Explain locations.
(b) Explain restrictions.
(c) Describe tie down provisions and explain how to tie down baggage.
(d) Explain door warning system.
(e) Give tips on loading.
(f) Warn against putting or allowing children in a baggage compartment.
(g) Warn against carrying hazardous material anywhere in the airplane.

7.19 Seats, Seat Belts, and Shoulder Harnesses

(a) Describe how to adjust the seats.
(b) Explain how to use the seat belts and shoulder harnesses.
(c) Include warnings and restrictions.

7.21 Doors, Windows and Exits

(a) Describe how to operate and lock doors, windows and exits.
(b) Explain any procedures or warnings necessary for the doors, exits, windows or windshield wipers.
(c) Discuss how to close a door or window if it opens accidentally in flight and any restrictions there may be on purposely opening in flight.
(d) Give precise instructions for using emergency exits.

7.23 Control Locks

(a) Explain how to engage control locks or secure control surfaces.
(b) Warn against forgetting to remove control locks.

7.25 Engine

(a) Describe the engine, giving the following as deemed necessary:
  1. Manufacturer and model number
  2. Type of engine-number of cylinders, type of compressor, etc.
  3. Rated power
  4. Rated engine speed
  5. Gear reduction if applicable
  6. Accessories normally installed
  7. Supercharging/Turbocharging or other augmentation
  8. Explain restrictions, warnings, tips
(b) Describe the engine controls including:
  1. Throttle or power control
  2. Propeller control
  3. Mixture control
  4. Cooling controls
  5. Turbocharger controls
  6. Friction lock
(c) Describe the engine instrumentation
  1. Describe briefly the method of operation
  2. Give limits of readings and typical values where applicable
(d) Proper operation and care of the engine when new and after the break in period should be described.
(e) Describe the lubrication system including:
  1. Type of system
  2. Instrumentation
(f) Describe ignition system
(g) Describe the air induction system including:
  1. Path of flow of the air
  2. Icing protection
  3. Filtering
  4. Supercharging/Turbocharging
  5. Explain restrictions, warnings, tips
(h) Describe the exhaust system including carburetor heat, muff heater, and flow to turbocharger (if appropriate).
(i) Describe the carburetor or fuel injection system including provisions for priming.
(j) Describe the cooling system including cowl flaps.
(k) Describe the engine starting system.
(l) Describe simply the accessories including:
  1. Oil pump
  2. Fuel pumps

3. Hydraulic pump
4. Air pump
5. Tachometer
6. Torque meter
7. Electrical power source
8. Propeller synchronizer
9. Exhaust gas temperature probe

(m) Describe any unique engine mounts including shock mounts.
(n) If an engine fire detection or extinguishing system is available, describe, give principle of operation, and explain how to use these.
(o) Describe any gear reduction system in the engine.
(p) Abnormal operations should be discussed briefly. This should be held to the minimum that will help a pilot to correct a situation or enable him to describe it to a mechanic. It should not be a maintenance procedure.

7.27 Propeller

(a) Describe the propeller and its operation if pitch can be varied.
(b) Explain how the propeller should operate.
(c) If appropriate, discuss feathering, unfeathering, and reversing.
(d) Explain cautions, warnings, restrictions, and idiosyncrasies.
(e) A cutaway drawing of variable pitch propellers may be included.

7.29 Fuel System

(a) Describe the system, provide a good schematic. and explain the operation.
(b) Discuss unusable fuel.
(c) Explain fuel management.
(d) Explain how to avoid and notice fuel contamination.
(e) Explain and discuss how the heater gets fuel (if appropriate).
(f) Explain crossfeed and fuel transfer (if appropriate).
(g) Discuss the fuel venting system and consequence of allowing it to become plugged.
(h) Explain the fuel measurement system and discuss need for monitoring and calibrating.
(i) Explain restrictions, warnings and operating tips.

7.31 Hydraulic System

(a) Explain what items use hydraulic pressure.
(b) Describe the primary and auxiliary systems.
(c) Provide one or more schematic diagrams of the system.
(d) Describe controls and instrumentation of the system.
(e) Discuss normal operation.
(f) Discuss abnormal operation.
(g) Explain restrictions, warnings and operating tips.

7.33 Brake System

(a) Describe the brake system.
(b) Discuss how to get maximum braking and maximum life out of the brakes.
(c) Explain how to recognize impending problems and what to do if malfunctions occur.
NOTE: At the manufacturer's option, brake system description and discussion may be covered under paragraph 7.15, Landing Gear.

7.35 Power Steering

If nose wheel power steering is installed:

(a) Describe the system.
(b) Explain how to use it.
(c) Discuss restrictions.

7.37 Electrical System

(a) Making use of simplified schematics and drawings explain how this system operates, including warning devices and control features in use.
(b) Discuss capacity and load shedding.
(c) Explain circuit protection.
(d) Discuss use of ground power units and battery charging.
(e) Explain restrictions, warnings and operating tips.

7.39 Lighting Systems

(a) Describe the various interior and exterior lighting systems.
(b) Explain how to troubleshoot malfunctions.
(c) Discuss how to check and operate the systems.

7.41 Auxiliary Power Unit

(a) If the airplane has a built-in auxiliary power unit, describe it and explain how it fits in with the electrical system.
(b) Explain operation of the unit.
(c) Explain restrictions and warnings.

7.43 Heating, Ventilating, Defrosting And Air-Conditioning Systems

(a) Using drawings as aids, describe each of the systems.
(b) Explain how to get maximum benefit and control using the controls provided.

7.45 Cabin Pressurization System

If the airplane is pressurized:

(a) Describe the system.
(b) Explain how to operate it.
(c) Explain how this system ties in with the heating, ventilating, defrosting and air-conditioning systems.
(d) Explain how to recognize potential problems and handle emergencies.

7.47 Oxygen System

(a) Describe the oxygen system if one is offered.
(b) Discuss restrictions or warnings.

7.49 Pitot Pressure Systems

(a) Describe the pitot pressure systems.
(b) Explain anti-icing provisions, if installed

7.51 Static Pressure Systems

(a) Describe the static pressure systems.
(b) Explain the alternate static systems if available.
(c) Discuss effects of heating and ventilating systems and of open windows on the alternate static system.
NOTE: At the manufacturer's option, static pressure systems description and discussion may be combined with Paragraph 7.49, Pitot Pressure Systems.

7.53 Vacuum Or Pneumatic System

(a) Using schematic diagrams describe the system and the items which use it.
(b) Explain how de-icing boots tie in with the system, if installed.
(c) Explain how the system can be checked.
(d) Discuss how a failing system can be recognized.
(e) Discuss restrictions and warnings.

7.55 Automatic Devices In The Control System

(To be included at manufacturer's option)

(a) Describe in simple terms the devices which are offered.
(b) Explain how to check and operate the devices.
(c) Discuss how to recognize a malfunction and how to handle the situation.

7.57 Stall Warning Or Angle of Attack System

(a) If either of these devices is installed explain whether it is required equipment.
(b) Explain the principle of operation.
(c) Explain how to check the system and use it.
(d) Discuss how to recognize a malfunction and when not to depend on it.

7.59 Icing Equipment

(a) Describe anti-icing or de-icing equipment available, and list that required for flight through known icing conditions.
(b) Describe how each item
1. Operates,
2. Can be checked,
3. Can be recognized as malfunctioning,
4. Might be corrected if malfunctioning.
(c) Explain restrictions imposed on each item.

7.61 Avionics (To be included at manufacturer's option)

(a) Describe items which are standard and explain their function and how they are operated.
(b) Refer to Section 9, supplements for description and/or operating instructions for avionic equipment which is installed.

7.63 Comfort Features

(a) Items such as toilets, relief tubes, sinks, etc. may be described and explained.

7.65 Cabin Features

(a) Special features such as storm window, fire extinguisher, food bar, tape players, special doors, etc. may be described and their use explained, if standard.

7.67 Windshield Wipers

(a) Explain how to operate windshield wipers if installed.
(b) Explain any restrictions.
(c) Describe how to correct a malfunction.

SECTION 8

HANDLING, SERVICING AND MAINTENANCE

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SECTION 8

HANDLING, SERVICING AND MAINTENANCE

8.1 General

This Section of the Pilot's Operating Handbook shall describe ways an operator of an airplane can ensure that the necessary handling, servicing and maintenance of the airplane can be accomplished. The user of this Handbook is the pilot - a person of undefined background - not a mechanic or technician.

An appropriate warning or note shall be contained in this Section to inform the operator that he is responsible for ensuring that all airworthiness directives are complied with and that the handling, servicing and maintenance of the airplane is done when required and in accordance with the Federal Aviation Regulations. In order to meet this responsibility, this Section should contain -

(a) A recommendation that airplane operator establish contact with the dealer or certified service station for service and information;

(b) A recommendation that all correspondence regarding the airplane include the airplane serial number (state where the serial number can be found); and

(c) A notation that service manuals and part catalogs are available and an explanation as to how these may be procured and kept up to date.

8.3 Airplane Inspection Periods

This paragraph shall contain information on the airplane (and components thereof) inspection periods. It should cover FAA required inspections (such as the annual and, in some cases, the 100 hour inspections) and manufacturer recommended inspections (such as the daily, 25-hour, 50-hour, etc.). Special inspection intervals for airplane systems and, possibly, for life limited parts, may be covered in this paragraph or there may be a reference to another section or another document where such inspection intervals may be found. This paragraph should also explain that, in addition to the established inspections, other inspections may be required by Airworthiness Directive. There should be a reference to the Federal Aviation Regulation (FAR's 43 and 91 or other applicable regulations) as to who may perform the required and manufacturer recommended inspections.

8.5 Preventive Maintenance That May Be Accomplished By A Certificated Pilot

(a) A certificated pilot who owns or operates an airplane not used as an air carrier is authorized by FAR Part 43 to perform limited preventive maintenance on his airplane. The Handbook should refer to FAR Part 43 for list of things the pilot may do.

Pilots operating aircraft of other than U.S. registry should refer to the regulations of the country of certification for information on preventive maintenance that may be performed by pilots.

(b) Include note to state that all other maintenance required on airplane is to be accomplished by appropriately licensed personnel and that airplane dealer or service station should be contacted for further information.

(c) Include note to state that preventive maintenance should be accomplished in accordance with the appropriate airplane service or maintenance manual. The Handbook should advise pilots to obtain a service manual prior to performing preventive maintenance to be sure that proper procedures are followed.

8.7 Alterations or Repairs to Airplane

(a) Note that alterations or repairs to airplane must be accomplished by licensed personnel.

(b) Point out that the FAA should be contacted prior to any alterations on airplane to insure that airworthiness of the airplane is not violated.

8 .9 Ground Handling

Discuss the following items:

1. Towing procedure
2. Parking
3. Tie down or mooring
4. Jacking and leveling

8.11 Servicing

Include information for servicing the aircraft with proper fuel and oil. Note any necessary precautions that should be observed.

8.13 Cleaning and Care

(a) Cleaning procedures for the following aircraft elements should be provided:

1. Exterior Cleaning such as:
   Painted surfaces
   Propeller
   Engine
2. Interior Cleaning such as:
   Wood surfaces
   Metal surfaces
   Cloth surfaces
   Leather surfaces
   Plastic trim
   Carpets
   Toilets

(b) Items to be included in the cleaning procedure should be:
Recommended cleaning agents.
Caution notes regarding use of unauthorized cleaning agents and possible hazards of using authorized ones.

8.15 Prolonged Out-of-Service Care

Include information for preparing the airplane for prolonged out-of-service care and for returning the airplane to service.

SECTION 9

TABLE OF CONTENTS SUPPLEMENTS

SECTION 9

SUPPLEMENTS

9.1 General

(a) This Section of the Pilot's Operating Handbook shall contain the appropriate Supplements (operating information) necessary to safely and efficiently operate the airplane when equipped with the various optional systems and equipment not provided with the standard airplane.

(b) Supplements may be prepared by the Handbook producer, supplied to the Handbook producer by the equipment supplier and inserted, as supplied, into the Handbook, or supplied to the airplane owner when he purchases new equipment after the airplane (and Handbook) has been delivered. The content of this Section of the Specification should be interpreted so as to foster the goal of providing the necessary information to the pilot.

(c) The Table of Contents required by paragraph 0.9 of this Specification may be in the form of a log (or list) of the Supplements. A log of additions of or revisions to Supplements, if needed ,may be incorporated into this Section instead of the Log required by paragraph 0.43 of this specification.

9.3 Supplement Scope

Each Supplement shall normally cover only a single system, device, or piece of equipment such as an autopilot, electric trim, or an area navigation system. Systems consisting of several components, such as ice protection systems, may have Supplements for each component, such as propeller boots, wing and empennage boots, or heated airspeed static source, if the equipment is FAA Approved by component and marketed individually. The effect of anti-icing or de-icing systems on the approval of the airplane for operating in known icing conditions should be clearly defined in the limitations section of the supplements.

9.5 Supplement Issuance

All Supplements for any particular airplane shall be issued by one or the other of the methods below:

(a) All Supplements may be issued to all owners of the airplane model covered by the Handbook. This method is recommended as minimizing errors of distribution, and also informs owners of the availability of systems and equipment.

(b) Supplements may be issued only to owners of airplanes equipped with the subject systems or equipment. This results in tailored Pilot's Operating Handbook and considerable record keeping;

9.7 Supplement Identification

Unless the Supplements are integrated within this Section of the Handbook (and thus derive their approval from approval of the Handbook), each Supplement shall have a cover or title page with the unique supplement identification, date of issue (or revision, it appropriate) and signature and title of the certificating or approving authority.

9.9 Page Numbering

Supplement page numbers shall consist of a statement of the consecutive page numbers, such as "1 of 5", "2 of 5", etc.

9.11 Structure of Supplements

Each Supplement shall be a self-contained, miniature Pilot's Operating Handbook with the following as a minimum:

(a) *Section 1, General.* The purpose of the Supplement and the systems or equipment to which it specifically applies shall be stated. FAA Approved Supplements shall be identified as such, and it shall be made clear that when the subject system or equipment is installed, the associated Supplement must be in the Pilot's Operating Handbook at all times.

(b) *Section 2, Limitations.* Any changes to the limitations, instrument markings, or placards of the basic Limitations (Section 2) of the Pilot's Operating Handbook shall be stated. If there is no change, a statement to that effect shall be made.

(c) *Section 3, Emergency Procedures.* Emergency Procedures associated with the subject installation shall be presented in a checklist form when order of action is essential to safety, and any changes to the basic Emergency Procedures (Section 3) of the Pilot's Operating Handbook shall be stated. If there is no change, a statement to that effect shall be made.

(d) *Section 4, Normal Procedures.* Normal Procedures associated with the subject installation shall be presented in a check list form when order of action is essential to safety, and any changes to the basic Normal Procedures (Section 4) of the Pilot's Operating Handbook shall be stated. If there is no change, a statement to that effect shall be made.

(e) *Section 5, Performance.* The effect, if any, of the subject installation upon airplane Performance as shown in the basic Performance (Section 5) of the Pilot's Operating Handbook shall be indicated. If there is no change, a statement to that effect shall be made.

SECTION 10

SAFETY AND OPERATIONAL TIPS (OPTIONAL)

TABLE OF CONTENTS

SECTION 10

SAFETY AND OPERATIONAL TIPS (OPTIONAL)

10.1 General

A Safety and Operational Tips section may be incorporated in the Handbook. It may contain:

Safety information of a general nature, such as--

(1) kinds of information and rules to be found in FAA publications;

(2) how to conduct various airplane inspections;

(3) medical problems and information (vertigo, hypoxia, fatigue, affects of scuba diving, etc.); and

(4) any other information that would enhance the safe use of the airplane.

(5) Child restraint systems:

A small child should use an approved child restraint seat. The child should not be held or share a seat belt with another person.

Acceptable child restraint seats are defined in publications such as Advisory Circular 91-62.

Operational tips of a general nature, such as -

(1) general weather information and sources and how to use the information;

(2) general fuel conservation information (such as why it pays to keep the exterior of the airplane clean);

(3) tips on operating in mountainous areas (or in desert areas or on grass or gravel runways, etc.); and

(4) any other information that would enhance the operational use of the airplane.

ALPHABETICAL ORDER

At the option of the manufacturer, a comprehensive alphabetical index may be included following the last section in the handbook.

(Optional)

SPECIFICATION FOR CONTINUING AIRWORTHINESS PROGRAM

(A Supplement to the Airplane's Maintenance Manual)

GAMA SPECIFICATION NO. 7

issued: March, 1991
1st edition

prepared and published by
GENERAL AVIATION MANUFACTURERS ASSOCIATION
Suite 801
1400 K Street, NW
Washington, DC 20005
(202) 393-1500

The primary document containing the procedures for the continued airworthiness of an airplane is the airplane's maintenance manual. A document prepared in accord with this Specification supplements, and is designed for use with, that manual.

LIST OF EFFECTIVE PAGES

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PREFACE

This Specification was developed by the General Aviation Manufacturers Association as guidance for airplane, engine and component manufacturers in preparing Continuing Airworthiness Program Inspection Documents (which may also be called Continuing Airworthiness Programs or CAPs). CAPs may be prepared for all types of general aviation airplanes and components certificated under the applicable Federal Aviation Regulations.

A CAP supplements the airplane's maintenance manual (or Instructions for Continuing Airworthiness) which is the primary document containing the procedures for the continuing airworthiness of the airplane. Some airplanes, particularly relatively simple airplanes, may not need CAPs because adequate information to maintain their continuing airworthiness throughout their useful lives is contained in the airplane's maintenance manual. In such cases, a CAP need not be published. If a manufacturer elects to provide comprehensive inspection information to supplement the basic airplane maintenance manual, this Specification is an example of, and establishes a standard for, a Continuing Airworthiness Program Inspection Document. Instead of, or in addition to, this example of style and format for a CAP, a manufacturer may use its publication style manual or another appropriate style manual.

The Specification was developed with the objective of minimizing the cost to, and efforts of, general aviation airplane owners and operators and maintenance personnel by standardizing the format and general content of Continuing Airworthiness Programs. Standardization will enhance safety through uniform interpretation of inspection requirements contained in Continuing Airworthiness Programs prepared in accord with this Specification. For the purposes of this Specification, "airplane" refers to the airframe and all related components specified in the Type Certificate or made available as options by the airplane manufacturer.

This Specification has been developed in response to Federal Aviation Administration (FAA) Advisory Circular AC 91-60, The Continued Airworthiness of Older Airplanes, and Advisory Circular AC 91-56, Supplemental Structural Inspection Program for Large Transport Category Airplanes. These FAA advisory circulars provide specific information regarding continued airworthiness requirements for the manufacturer and owner/operator. Advisory Circular 91-56 provides "Guidelines for Development of Continuing Airworthiness Programs" to which this Specification closely adheres.

In addition to understanding FAA Advisory Circulars AC 91-60 and AC 91-56, familiarity with GAMA Specification No. 2, Manufacturers Maintenance Data and Air Transport Association of America Specification No. 100, Specification for Manufacturers Technical Data, will aid in the preparation of a CAP for a specific airplane.

It is intended that manufacturers retain and exercise reasonable judgement and latitude in the content of their publications with respect to depth and scope of coverage. In order to achieve the objectives of this Specification (enhance safety, reduce efforts, minimize costs), each manufacturer is expected to reasonably adhere to the Specification content and arrangement in order to provide consistent, industry standardized Continuing Airworthiness Programs. If a company publication style manual is used (so as to maintain continuity of the company "style" for all of its publications), the format and layout should follow this Specification to the extent practicable.

This Specification contains references to the Federal Aviation Administration (FAA) and the Federal Aviation Regulations (FARs). If the Specification is used to prepare a Continuing Airworthiness Program for acceptance by an airworthiness authority other than FAA, the appropriate authority and its regulations may be substituted.

Questions on interpretation and proposed changes to this Specification should be submitted to General Aviation Manufacturers Association, Suite 801, 1400 K Street, N.W., Washington, D.C. 20005.

CONTENTS

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SECTION I - PHYSICAL REQUIREMENTS

1. **Binder Type and Page Size**

Documents must be readily revisable. They may be in loose-leaf form with a durable, multi-ring cover, permanently bound, "Fiche", or another appropriate form. If in loose-leaf form, use "standard", or commonly used page sizes.

2. **Paper, Printing and Type Size**

Use white paper with good strength characteristics and of sufficient weight and substance to eliminate excessive show-through when printed on both sides. In meeting these requirements, consideration may be given to limiting paper bulk. Use a form of printing that results in a black image suitable for reproduction. Copy density must be uniform throughout the page.

Print interim changes (interim to a republication of the document), except fiche or microfilm copy, on colored stock. Weight and substance may be governed by the printing process used.

Prepare basic text in 10- or 12-point type. Use 14-point uppercase bold for the word **WARNING** and 10-point uppercase bold for the **WARNING TEXT**. Use 12-point uppercase bold for the word **CAUTION** and 10-point uppercase for the CAUTION TEXT. Use 10-point uppercase bold for the word **NOTE** and 10-point mixed case for the Note Text. First, second and third level heads and captions should be distinctive in size or style or both. Type style is determined by the Document producer based on the equipment available and good judgement. See Figure 1-1.

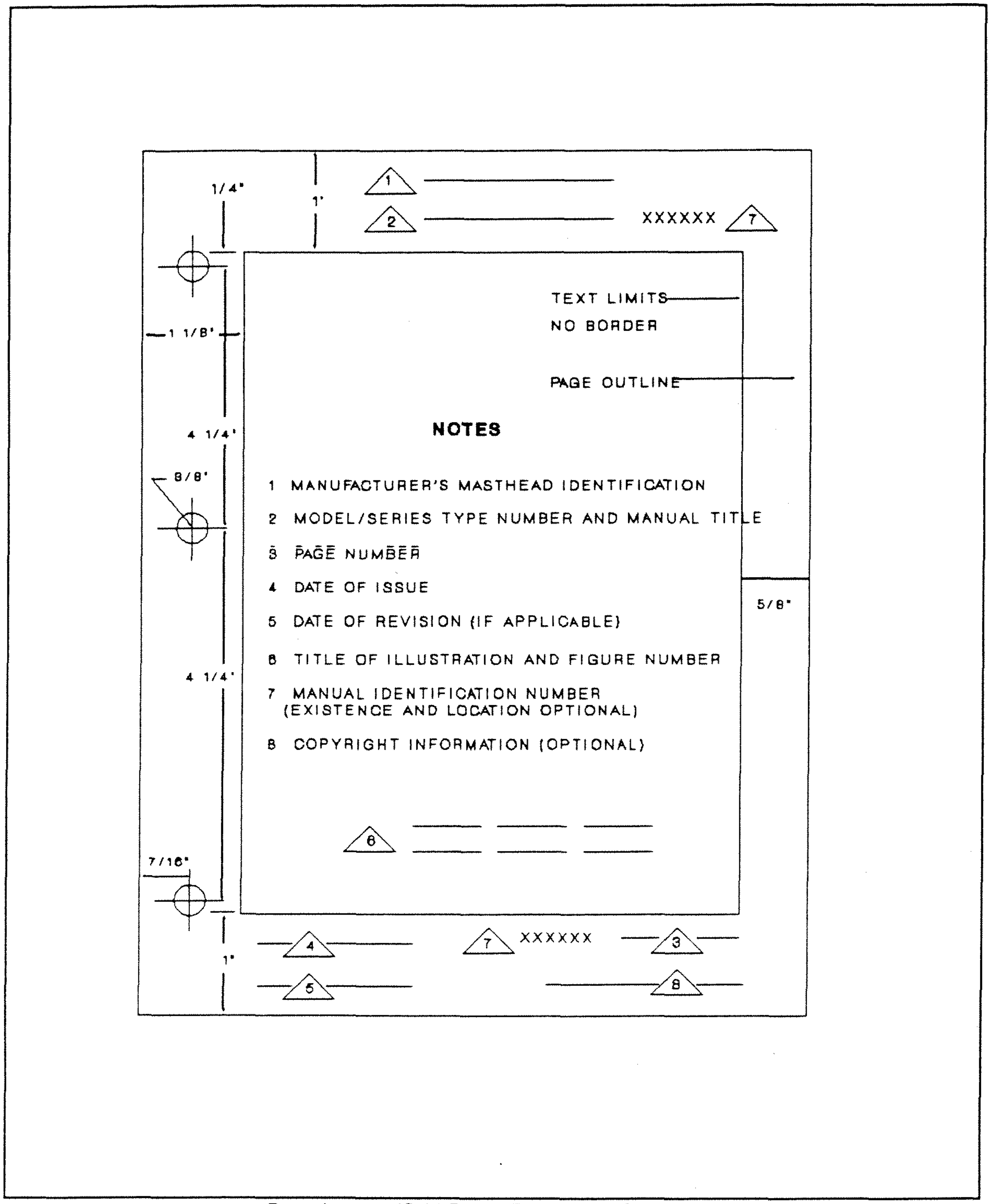
3. **Page Identification**

Number the pages of CAPs containing only one section in sequence with section identification. Number the pages of multi-section CAPs with section number and a dash (i.e., "1-" for all pages in the "Physical Requirements" section) followed by the serial number of the page beginning with "1" for each section (e.g., Page 1-1, 1-2, etc.)

Number the pages in each appendix with the Appendix letter (or number) and a dash (i.e., "G-" for all pages in the appendix) followed by the serial number of the page beginning with "1" for each appendix (e.g., Page G-1, G-2, etc.)

Print the page number and date of issue or revision at the bottom of each page. Locate the page number in the lower right corner and the date of issue in the lower left corner, for odd pages. Locate the page number in the lower left corner and the date of issue in the lower right corner, for even pages. See Figure 1-1.

Pages of permanently bound or "Fiche" Documents need not be dated. Table of Contents pages must be dated but need not be numbered.



Page Layout (Odd Page, Even Page Opposite)
Figure 1-1

Each page must 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 Document, 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 Document must bear the actual date of issue following the words "original issue".

On pages requiring folding, make the fold in a manner that permits the page number to be visible. Except as provided below, identify a normal blank page within a page block (other than the back of a foldout page) with a phrase such as "This page intentionally blank".

Instead of printing "This page intentionally blank" on blank pages, the Document 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 after the initial printing, use the number of the preceding page with a letter suffix added for the added page(s) (e.g., Page 1-6A, 1-6B, etc.).

4. **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. Print all pages except wiring diagrams and foldouts on both sides. Start each section on a right-hand page. The manufacturer's masthead, publication title, airplane model, and issue or revision date must appear on all pages of loose-leaf Documents that have text, illustrations, figures or tables .

5. **Tab Dividers**

Separate each Section and Appendix of a loose-leaf Document with a plasticized tab divider. Stagger the tab dividers and label them with section numbers or titles, or both. Separation of sections in permanently bound CAPs is not required.

6. **Identifying Revised Material**

Identify revisions, additions and deletions by a vertical black line along the outside of the page (or the column side opposite the gutter on two column pages) opposite only that portion of the printed matter that was changed. Identify a revision to an illustration with a black vertical line in the left margin opposite the revised portion or use a "pointing hand" (☛). Show the date of the revision on each revised page. See Figure 1-1.

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SECTION II - CONTINUING AIRWORTHINESS PROGRAM DOCUMENT PRESENTATION

1. **Contents**

A Continuing Airworthiness Program Inspection Document contains the following information:

A. Cover (optional).

B. Title Page.

C. Preface (optional if necessary information is covered in the Objectives).

D. List of Effective Pages.

E. Record of Revisions. (Optional if information is provided elsewhere.)

F. Table of Contents.

G. Applicability.

H. Objectives (optional if necessary information is covered in the Preface).

I. Technical Document Reference.

J. List of Continuing Airworthiness Program Inspections.

K. Continuing Airworthiness Program Inspections (in Chapter Number order).

2. **Explanation of Contents**

A. Cover.

(1) The cover title is Continuing Airworthiness Program Inspection Document for (list airplane names or models, or both, or the components).
(2) In the alternative, the acronym CAP may be used (with the airplane model or component names).
(3) Other information may be displayed on the cover. See Figure 3-1.

B. Title Page.

The Title Page contains the following information:

(1) The title, Continuing Airworthiness Program Inspection Document or the acronym CAP.
(2) The airplane model name or description or the components covered.
(3) The manufacturer's masthead or logo.
(4) A statement conveying the intent of the following example:

"The primary document containing the procedures for the continuing airworthiness of an airplane is the airplane's maintenance manual (Instructions for Continuing Airworthiness). A document prepared in accord with this Specification supplements, and is designed for use with, that maintenance manual."

(5) The effective date and revision number and date if applicable.
(6) The manufacturer's address.
(7) The part number, if applicable.

Additional information, such as GAMA membership identification, copyright notice, etc., may be included. Format and layout is to be determined by the CAP producer, recognizing that it is desirable that the format and layout be similar to the producer's existing documents.

NOTE: Back of the Title Page should be left blank except for items such as a Manufacturer's logo.

See Figure 3-2

C. Preface (optional if necessary information is covered in the Objectives).

The Preface contains the following information:
(1) The reasons for establishing the CAP program (discussion of service history) and the underlying problems to be prevented by compliance with the specific CAP.
(2) The relationship of the CAP to normal inspection programs for the product.

NOTE: The Preface has been omitted in the sample CAP in Section III and the necessary information has been included in the Objectives.

D. List of Effective Pages.

(1) The List of Effective Pages is formatted to provide:
   (a) A Chapter/Section/Subject column.
   (b) A page number column.
   (c) A date column.
(2) Revision instruction information (such as, "Insert Latest Revised Pages; Destroy Superseded or Deleted Pages") or revision history information, or both, may also be included.

See Figure 3-4.

E. Record of Revisions. (Optional if information is provided elsewhere.)

The Record of Revisions is formatted to provide:

(1) A Revision Number column.
(2) A Date Inserted column.
(3) A Date Removed column (optional).
(4) A Page Number column.

See Figure 3-5.

F. Table of Contents.

The Table of Contents is formatted to provide:

(1) A Title column.
(2) A Page Number column.

See Figure 3-6.

G. Applicability.

The Applicability Statement contains the following information, appropriately formatted:

(1) A list of models or components affected, in a column on the left side of the page, and a list of corresponding serial/unit numbers (or other identifying information), in a corresponding column on the right side of the page.
(2) Special information, such as exclusions or additions, in note form.

The listed model or components and listed serials/units are to be cumulative for all inspections in the Continuing Airworthiness Program Inspection Document. This will allow the user to identify an affected airplane by examining one list rather than having to check each individual Continuing Airworthiness Program's Inspection for applicability.

See Figure 3-7.

H. Objectives.

The Objectives Statement contains the following information:

(1) The relationship of the CAP to existing inspection programs and the manufacturer's objectives for the CAP.
(2) Optional information including (but not limited to) the rationale utilized to select CAPs - how the CAP requirements were determined (discussions of service history, tests and analyses).

The manufacturer may establish procedures to provide feedback (from operators and maintenance facilities who comply with a CAP) on unairworthy conditions (whether covered or not covered by the CAP) that were discovered when complying.

See Figures 3-8, -9, and -10.

I. Technical Document Reference.

The Technical Document Reference contains a listing of necessary service documents (e.g., service bulletins, service letters, service kits, etc.) and related information directly identified in a Continuing Airworthiness Program Inspection. Only service documents directly involved with a CAP need be listed, in order, with document number (if numbered), full title and date. Show a source for all listed documents.

See Figure 3-12.

J. Listing of Continuing Airworthiness Program Inspections.

(1) The *Listing of CAP Inspections contains all* Continuing Airworthiness Program Inspections in the CAP, in numerical order by CAP inspection number, with full title, date, effectivity and inspection compliance. See Figure 3-14.

(2) In the alternative, a block diagram, showing only Continuing Airworthiness Program Inspection numbers and time blocks may be used. See Figure 3-15.

K. Continuing Airworthiness Program Inspections.

(1) Continuing Airworthiness Program Inspections usually consist of two pages: one text page (see Figure 3-16) and one illustration page (see Figure 3-17).

(2) The Continuing Airworthiness Program Inspection contains the following sections, in order, from the top of the page to the bottom (except as noted), in bold face type or underscored:

(a) CONTINUING AIRWORTHINESS PROGRAM INSPECTION NUMBER - in the upper right corner of the image area on the text page(s) and, optionally, on the illustration page(s). The Continuing Airworthiness Program Inspection number is also displayed at the bottom of the page and is the CAP section number (see Note).

NOTE: The Continuing Airworthiness Program Inspection number is determined as follows:

XX XX XX

- Subject Number - To be determined by manufacturer, but generally numerically increasing with the number of individual inspections within the chapter/section group.
- Section Number - First digit determined by GAMA Specification No. 2 Numbering System. Second digit determined sequentially by the manufacturer.
- Chapter Number - Both digits determined by GAMA Specification No. 2 Numbering System.

(b) TITLE - at the top of the text page, at the left margin.

For example: FUSELAGE/WING ATTACHMENT INSPECTION.

(c) EFFECTIVITY - directly below the title; show both model and serial/unit numbers as applicable. Exceptions and additions are also noted here (such as "except airplanes incorporating Service Kit Number 999").

(d) INSPECTION COMPLIANCE - directly to the right of the effectivity and near the right margin. Instructions regarding "when" an inspection is required, and if repetitive, are located here. Also state if additional repetitive inspections are required based upon initial inspection results.

(e) PURPOSE - directly below the Effectivity and Inspection Compliance sections, extending from the left to the right margins. Any service history discussion is also located here.

(f) INSPECTION INSTRUCTIONS - directly below the Purpose section and extending from the left to the right margins.

(g) ACCESS/LOCATION - directly below the Inspection Instructions section, extending from the left to the right margins. Access and location instructions are provided here unless obvious.

For example: Remove wing attach fairings.

(h) SIGNIFICANT INSPECTION CONDITION (detectable crack size, wear limits, corrosion condition, etc.) - directly below the Access/Location section at the left margin. Specifies, for a crack inspection, the minimum size crack expected to be discovered or, if no minimum is defined, a statement to this effect. Specifies, for other inspection conditions, the wear limits, corrosion pit depth, etc.

(i) INSPECTION PROCEDURE - located directly below the Significant Inspection Condition section, extending from the left to the right margins. Sets forth the inspection procedure(s) to be utilized, such as; magnetic particle, visual, etc., and may reference another document for the actual procedure, such as a nondestructive testing manual.

(j) REPAIR/MODIFICATION - located directly below the Inspection Procedure section, extending from the left to the right margins. Sets forth repair or modification instructions and may refer to a standard repair in another document or a special repair or modification defined elsewhere, such as in a service kit, service bulletin, etc.

(k) COMMENTS - located directly below the Repair/Modification section, extending from the left to the right margins. Additional information or instructions, such as "Report any cracks found to this manufacturer", are contained here.

(l) SECTION NUMBER, PAGE NUMBER AND PAGE DATE - as indicated in Figure 3-16 or optionally, as shown in Section I - Page Numbers and Dates. The Continuing Airworthiness Program Inspection number becomes the section number and defines its placement within the CAP.

(m) RECOMMENDED OR REQUIRED RETIREMENT TIMES OF LIFE LIMITED PARTS (if established) - on the right side of the page in an appropriate space. Use of the word CAUTION, with appropriate 10-point uppercase for the text, enclosed in a box, is recommended. Sets forth manufacturer recommended retirement times for parts or assemblies (using hours, cycles or another appropriate determinant) and FAA required retirement (removal from service) times for life limited parts or assemblies.

SECTION III - SAMPLE CAP

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CONTINUING AIRWORTHINESS PROGRAM INSPECTION DOCUMENT (CAP)

FOR

Light Single Engine Aircraft
Model XXX Series

ABC Aircraft Company

CAP Cover
Figure 3-1

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CONTINUING AIRWORTHINESS PROGRAM
INSPECTION DOCUMENT (CAP)

LIGHT SINGLE ENGINE AIRCRAFT
MODEL XXX SERIES

issued: June, 1990
1st edition

prepared and published by
ABC AIRCRAFT COMPANY
1234 Anystreet Drive
Anytown, VA 99999
(555) 555-5555

This document provides **supplemental information** to the applicable airplane maintenance manual(s).

Member of GAMA

MANUAL IDENTIFICATION NUMBER

CAP Title Page
Figure 3-2

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Figure 3-3

CAP — ABC Model XXX

LIST OF EFFECTIVE PAGES

CHAPTER SECTION SUBJECT	PAGE	DATE
COVER		
TITLE PAGE		6/90
LIST OF EFFECTIVE PAGES	i	6/90
RECORD OF REVISIONS	ii	6/90
CONTENTS	iii	6/90
APPLICABILITY	iv	6/90
OBJECTIVES	v	6/90
	vi	6/90
	vii	6/90
SECTION I - TECHNICAL DOCUMENT REFERENCE	1-1	6/90
SECTION II - LISTING OF CONTINUING AIRWORTHINESS PROGRAM INSPECTIONS	2-1	6/90
	2-2	
SECTION III - CONTINUING AIRWORTHINESS PROGRAM INSPECTION	3-1	6/90
	3-2	6/90

Insert Latest Revised Pages
Destroy Superseded or Deleted Pages

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Issued: June, 1990

© 1990 ABC Aircraft Company

List of Effective Pages
Figure 3-4

ABC Model XXX CAP

RECORD OF REVISIONS

REVISION NUMBER	DATE INSERTED	DATE REMOVED	PAGE NUMBER	REVISION NUMBER	DATE INSERTED	DATE REMOVED	PAGE NUMBER

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Record of Revisions
Figure 3-5

CAP ABC Model XXX

CONTENTS

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Issued: June, 1990

Table of Contents
Figure 3-6

ABC Model XXX CAP

APPLICABILITY

MODEL	SERIAL
XXX	XXX-0001 THRU XXX-0577
XXX	XXX-0001 THRU XXX-0275
XXXX	XXXX-0276 THRU XXXX-1700
XXXX	XXXX-0001 THRU XXXX-0647
	REFER TO NOTE 1
XXX	XXX-57841 THRU XXX-58818
XXXX	XXX-0001 THRU XXX-0197

NOTE 1: XXX-0001 thru -0647 except airplanes incorporating SKXXX-XX.

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Applicability Statement
Figure 3-7

CAP ABC Model XXX

OBJECTIVE

1. Introduction

A. The Continuing Airworthiness Program Inspection Document (CAP) is inspection data that, when combined with the operator's existing maintenance program, will help maintain the structural integrity and continued airworthiness of the ABC XXX Series airplanes.

B. Although the airplanes addressed in this document are out of production, ABC continues to support them as outlined in our stated company policies. The factory has maintained technical assistance and parts support within stated policies. Service letters and owner information have been made available as necessary to maintain the airworthiness of the fleet. ABC has utilized condition report inputs to ensure maintenance and inspection guidelines are adequate and current by issuing updated guidelines when appropriate.

C. The airplanes were delivered with recommended inspection programs to keep them airworthy. Because of the varied missions the airplanes performed, type of care given, and age and utilization rates, ABC has determined, based on inspections, tests, and analyses, that it is necessary to provide additional inspection requirements to further ensure that the airplanes can continue to carry the design loads it was originally certified for.

D. This CAP has been developed in accordance with guidelines in FAA Advisory Circulars 91-56 and 91-60. The CAP is not intended to change or replace any portion of the applicable airplane Maintenance Manual or Service Letters.

E. Each Section, such as "Technical Document Reference", "Listing of Continuing Airworthiness Program Inspections", etc., starts a new page numbering sequence.

2. Objective

A. This CAP has been prepared with the intent to expand present inspection requirements as a further assurance of the ability of the airplane to perform within the limits of the original certification. The CAP will add confidence in using the airplane for its assigned mission.

B. The CAP will address primary and secondary airframe components, and primary and secondary systems to accomplish the stated objective of continued airworthiness.

C. To establish the basis for those items to be included, the following assumptions have been made.

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Issued: June, 1990

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Objectives Statement
Figure 3-8

(1) The airplane has been maintained in accordance with ABC recommendations or equivalent.

(2) Wherever the CAP is directed to a specific part or component, it is implied that the inspection will include observation and evaluation of the surrounding area of parts and equipment. Any maintenance anomaly would subsequently be brought to the attention of both the owner and maintenance personnel. Any anomaly should be reported to ABC, through the Condition Reporting System, so that additions and/or revisions can be made to the CAP where deemed necessary.

(3) Airplanes modified by STC are not the responsibility of ABC. Any item affected by STCs in ABC Manuals or CAPs must be brought to the attention of the STC holder by the owner or maintenance organization in order to obtain FAA-approved guidelines for the inspection, repair, preservation, etc. of that item.

3. Rationale Utilized to Select Inspection Items

A. Service Experience.

(1) Customer correspondence and service reports were reviewed during the section process for the critical inspection items. Some reports were used to select items that were similar in application, design and loading even though no failures have occurred.

(2) High-time airplanes, disassembled for major overhaul, were inspected to assist in selecting inspection items. Other high-time airplanes' special Continuing Airworthiness Program Inspection results supplement these inspections.

(3) The effects of corrosion have not been considered in the rationale in selecting inspection times or in the effects on the fatigue stresses. It is very difficult to determine the effects of corrosion but, as the reports from the CAP inspections are received, the inspection times will be adjusted for any severe problems.

B. Testing.

(1) A review of test results applicable to the design was made. The loading conditions together with the resulting margins of safety were evaluated. The resulting data were used to determine if the component should be considered for incorporation into the CAP.

C. Analysis.

(1) Existing analyses were reviewed to identify components and areas that may have exhibited lower margins of safety.

 Issued: June, 1990

Objectives Statement (Continued)
Figure 3-9

CAP

ABC Model XXX

4. Reporting/Compliance

A. For the CAP to be successful on a continuing basis, it is essential that a free flow of information exist between the operator, FAA and ABC Aircraft Company. The significant details of inspection results, repairs and modifications accomplished must be communicated to ABC Aircraft Company in order to assess the effectiveness of the recommended inspection procedures and time intervals. In some cases, extension of inspection frequencies may be possible if the data suggests that the onset of fatigue problems occurs at a greater number of flight hours than initially predicted.

B. Additionally, items not previously considered for inclusion in the CAP may be uncovered through operator inspections. These items will be evaluated by ABC and, if applicable to the airplane configurations concerned, will be added to the document for the benefit of all.

C. A reporting system, consistent with the systems employed by ABC Service Organization, has been established and incorporated into this document. Copies of the appropriate forms and a description of the entries to be completed are available to you from an ABC dealer or Factory Customer Service Representative.

<u>NOTE:</u> This system does not supersede the normal channels of communication for items not covered by the CAP.

The discrepancy report should include the following:

Continuing Airworthiness Program Inspection Number
Airplane Model and Serial Number
Airplane Hours
Title of Continuing Airworthiness Program Inspection
Location and Description of the Damage
How Detected

The operator may use standard ABC Condition Report form(s) or an equivalent containing the same information.

Send all available data, including repairs, Polaroid photos, etc., to:

Service Department
Attn: CAP Program
ABC Aircraft Company
1234 Anystreet Drive
Anytown, VA 99999

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Objectives Statement (Continued)
Figure 3-10

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Figure 3-11

CAP ABC Model XXX

SECTION I - TECHNICAL DOCUMENT REFERENCE

MAINTENANCE MANUALS

Number	Title	Date
Model XXX	Maintenance Manual	8/1/85

SERVICE BULLETINS

SBXXX-XX-X	Wings - Main Wing Spar Modification	9/1/89
SBXXX-XX-X	Stabilizers - Vertical Stabilizer Tip Rib Modification	8/1/89

To obtain a Maintenance Manual for the Model XXX Series airplane and the listed Service Bulletins, write to:

Documents Department
ABC Aircraft Company
1234 Anystreet Drive
Anytown, VA 99999

1-1

Issued: June, 1990

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Tech^Xxcal Document Reference
Figure 3-12

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Figure 3-13

CAP ABC Model XXX

SECTION II - LISTING OF CONTINUING AIRWORTHINESS PROGRAM INSPECTIONS

Continuing Airworthiness Program Inspection Number	Title	Date	Effectivity	Inspection Compliance Initial	Inspection Compliance Repeat
32-30-01	Main Landing Gear Act Mounting Bolts	7/28/89	1970 Model XXX Series & On	500 Hrs.	500 Hrs.
32-30-02	Main Gear Downlock Actuator	7/28/89	Model XXX, XXXX & XXXX (1970 thru 1986 Models)	1000 Hrs. or Annual	1000 Hrs. or Annual
32-50-01	Nose Gear Turning Stop	6/28/89	Models XXX, XXX and XXX Series	3000 Hrs.	1000 Hrs.
32-50-02	Nose Gear Steering Collar and Upper	7/28/89	All Models XXX's and XXX's, 2157841 & On	3000 Hrs.	1000 Hrs. See 32-50-02
53-10-01	Pressurized Cabin Inspection	7/28/89	XXXXXXXX & On	5000 Hrs.	3000 Hrs.

2-1

Issued: June, 1990

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Listing of Continuing Airworthiness Program Inspections (List Form)
Figure 3-14

CONTINUING AIRWORTHINESS PROGRAM INSPECTIONS CHECK LIST

Continuing Airworthiness Program Inspection Number	500 Hrs.	1000 Hrs.	3000 Hrs.	5000 Hrs.
32-30-01	Initial & Repeat			
32-30-02		Initial & Repeat		
32-50-01		Repeat	Initial	
32-50-02		Repeat	Initial	
53-10-01			Repeat	Initial

Listing of Continuing Airworthiness Program Inspections (Block Form)
Figure 3-15

CAP ABC Model XXX

SECTION III - CONTINUING AIRWORTHINESS PROGRAM INSPECTIONS

TITLE CONTINUING AIRWORTHINESS INSPECTION NUMBER: **53-40-03**

Fuselage/Wing Attachment Fitting

EFFECTIVITY

All XXX Series Aircraft - 1967 & On

INSPECTION COMPLIANCE

INITIAL XXXX Hrs. or Annual
REPEAT XXXX Hrs. or Annual

PURPOSE

To check Fuselage/Wing Attachment Fitting.

INSPECTION INSTRUCTIONS

1. Reference SEB83-XX and Item 53-40-04 of this CAP.
2. See Figure on page 2.
3. Refer to the appropriate manufacturer's Service Manual.

ACCESS/LOCATION

Main spar wing attach fittings. - Remove wing attach fairings. Do not remove dowel pins unless required in complying with Continuing Airworthiness Inspection Number 53-40-04.

DETECTABLE CRACK SIZE

.060 Inch.

CAUTION:
REPLACE NUTS AND WASHERS IF REMOVED DURING INSPECTION. DO NOT REUSE.

INSPECTION PROCEDURE

Visual.

REPAIR/MODIFICATION

Replacement.

COMMENTS

Report any cracks found to this manufacturer.

53-40-03 3-1

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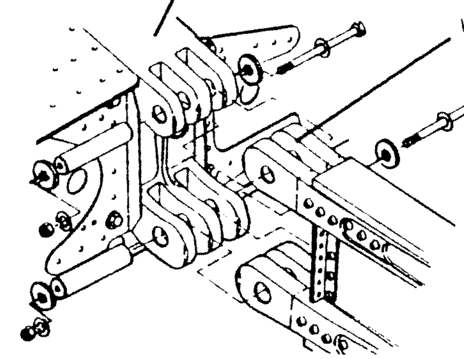
Continuing Airworthiness Program Inspection
Figure 3-16



NOTE

REMOVE FILLETS AND INSPECT FUSELAGE-TO-WING ATTACHMENT AT EACH XXXX-HOUR INSPECTION. CHECK DOWEL PIN RETAINING HARDWARE, CARRY-THRU SPAR, AND WING FITTINGS THOROUGHLY.

Figure 3-1 - Fuselage/Wing Attachment Fitting

Continuing Airworthiness Program Inspection
Figure 3-17