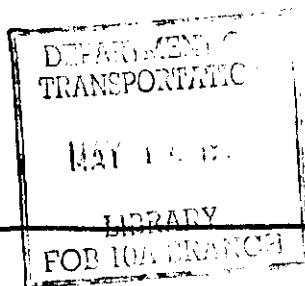


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ADVISORY CIRCULAR



DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Washington, D.C.

Subject: AIRCRAFT WEIGHT AND BALANCE CONTROL

1. PURPOSE. This advisory circular provides a method and procedures for developing a weight and balance control system.
2. FOCUS. This document is appropriate for the guidance of that segment of the public which is required to have an approved weight and balance program by Federal Aviation Regulations, Parts 121 and 127, or elects to have an approved program under Part 135.
3. CANCELLATION. Advisory Circular 120-27, Aircraft Weight and Balance Control, dated October 15, 1968, and Advisory Circular 135-1C, Air Taxi Aircraft Weight and Balance Control dated February 10, 1977, are canceled.
4. DISCUSSION. The operator may submit, for inclusion in their operations specifications, any method and procedure by which it can be shown that the aircraft will be properly loaded and will not exceed approved weight and balance limitations during operation. The approval of such a weight and balance control system is based on an evaluation of the program presented for a particular aircraft, and of a particular operator's ability to implement that program. By whatever method used, the program should account for all probable loading conditions which may be experienced in service, and show that the loading schedule developed will ensure satisfactory aircraft loading, within the approved limits, throughout each flight.
5. CONTENTS. Weight and balance control systems encompass the following:
 - a. Methods for establishing, monitoring and adjusting individual aircraft or fleet empty weight and center of gravity (CG) in conjunction with the initial and periodic reweighing of aircraft.
 - b. A loading schedule composed of graphs, tables, computers, etc., whereby the various weight and balance conditions of an aircraft may be established based on pertinent data for use in loading that particular aircraft in a rapid and satisfactory manner.

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c. Procedures for using the loading schedule, to establish that the loaded condition of the aircraft is within approved weight and CG limits.

d. A load manifest to document loading information by personnel responsible for weight and balance control, together with procedures for its preparation.

e. Procedures for crewmembers, cargo handlers, and other personnel concerned with aircraft loading, giving complete details regarding distribution of passengers and fuel, distribution of cargo, and necessary restrictions to passenger movement during flight.

6. TERMS, DESCRIPTIONS, AND GENERAL STANDARDS.

a. Empty weight. The empty weight of an aircraft is the maximum gross weight less the following:

(1) All fuel and oil, except system fuel and oil. System fuel and oil is that amount required to fill both systems and the tanks, where applicable, up to the outlets to the engines. When oil is used for propeller feathering, such oil is included as system oil.

(2) Crew and crew baggage.

(3) Drainable antidetonant injection, augmentation, and deicing fluids.

(4) Passengers and cargo (revenue and nonrevenue).

(5) Removable passenger service equipment, food, magazines, etc., including drainable washing and potable water.

(6) Emergency equipment (overwater, tropical, frigid).

(7) Other equipment, variable for flights.

(8) Flight spares (spark plugs, wheel, cylinder, etc.).

b. Operating weight. The operating weight established by the operator for a particular model aircraft should include the following standard items in addition to the empty weight of the aircraft or as otherwise specified by the operator.

(1) Normal oil quantity.

(2) Antidetonant injection, augmentation, and deicing fluids.

(3) Crew and crew baggage.

(4) Passenger service equipment including washing and potable water, magazines, etc.

(5) All other items of equipment considered standard by the operator concerned.

(6) Emergency equipment, if required, for all flights.

c. A detailed listing of the items comprising empty weight and operating weight should be included in the operator's program.

d. Structural limits. Weight and center of gravity limits are established at the time of aircraft certification. They are specifically defined for the aircraft to which they apply, and are included in, or referenced by, the applicable type certificate data sheet. The operator's weight and balance program should provide for maintaining these limits. Following are general definitions of structural weight limits normally considered in a weight and balance program.

(1) Maximum zero fuel weight. The zero fuel weight limit of an aircraft is the maximum weight authorized for the loaded aircraft without wing fuel. The weight of fuel carried in the fuselage, or designated as fuselage weight by the manufacturer, is considered as zero fuel weight.

(2) Maximum landing weight. The landing weight limit is the maximum weight at which the aircraft may normally be landed. Some aircraft are equipped to jettison fuel as an abnormal measure to reduce aircraft weight down to the landing limit.

(3) Maximum takeoff weight. This is the maximum allowable total loaded aircraft weight at the start of the takeoff run.

(4) Maximum ramp weight. This is the maximum allowable loaded aircraft weight for taxi.

e. The program should provide for operational performance factors such as takeoff and landing runway accountability and enroute and taxi fuel burnoff.

7. AIRCRAFT WEIGHT ESTABLISHMENT. Aircraft weight and balance control systems normally contain provisions for determining aircraft weight in accordance with the following procedures:

a. Individual aircraft weight and changes. The loading schedule may utilize the individual weight of the aircraft in computing pertinent gross weight and balance. The individual weight and CG position of each aircraft should be reestablished at the specified reweighing periods. In addition, it should be reestablished (by computing or reweighing) whenever the cumulative change to the operating weight exceeds plus or minus one-half of 1 percent of the maximum landing weight or the cumulative change in CG position exceeds

one-half of 1 percent of the mean aerodynamic chord (MAC). In the case of helicopters, whenever the cumulative change in CG position exceeds one-half 1 percent of the CG range, the weight and balance should be reestablished.

b. Fleet weights, establishment, and changes. For a fleet or group of aircraft of the same model and configuration, an average operating fleet weight may be utilized if the operating weights and CG position are within the limits established herein. The fleet weight should be calculated on the following basis:

(1) An operator's empty fleet weight is usually determined by weighing aircraft according to the following table: for fleets of 1 to 3, weigh all aircraft; for fleets of 4 to 9, weigh 3 aircraft plus at least 50 percent of the number over 3; for fleets of over 9, weigh 6 aircraft plus at least 10 percent of the number over 9.

(2) In choosing the aircraft to be weighed, the aircraft in the fleet having the highest time since last weighing should be selected. When the average empty weight and CG position have been determined for aircraft weighed and the fleet operating weight (winter and summer, if applicable) established, necessary data should be computed for aircraft not weighed but which are considered eligible under such fleet weight. If the operating weight of any aircraft weighed, or the calculated operating weight of any of the remaining aircraft in the fleet, varies by an amount more than plus or minus one-half of 1 percent of the maximum landing weight from the established operating fleet weight or the CG position varies more than plus or minus one-half of 1 percent of the MAC from the fleet weight CG, that aircraft should be omitted from that group and operated on its actual or calculated operating weight and CG position. If it falls within the limits of another fleet or group, it may then become part of that fleet. In cases where the aircraft is within the operating fleet weight tolerance but the CG position varies in excess of the tolerance allowed, the aircraft may still be utilized under the applicable operating fleet weight but with an individual CG position.

(3) Reestablishment of the operator's empty fleet weight or operating fleet weight and corresponding CG positions may be accomplished between weighing periods by calculation based on the current empty weight of the aircraft previously weighed for fleet weight purposes. Weighing for reestablishment of fleet weights is normally conducted on a 3-year basis unless shorter periods are desired by the operator.

c. Establishing initial weight. Prior to being placed into service, each aircraft should be weighed, and the empty weight and center of gravity location established. New aircraft are normally weighed at the factory and are eligible to be placed into operation without reweighing if the weight and balance records have been adjusted for alterations or modifications to the aircraft. Aircraft transferred from one operator with an approved weight and balance program to another operator with an approved program need not be weighed prior to use by the receiving operator unless more than 36 calendar months have elapsed since last weighing.

d. Periodic weighing - aircraft using individual weights. Aircraft operated under a loading schedule utilizing individual aircraft weights in computing the gross weight are normally weighed at intervals of 36 calendar months. An operator may, however, extend this weighing period for a particular model aircraft, when pertinent records of actual routine weighing during the preceeding period of operation show that weight and balance records maintained are sufficiently accurate to indicate aircraft weights and CG position are within the cumulative limits specified in paragraph 7a. Such applications should be limited to increases in increments of 12 months and should be substantiated in each instance with at least two aircraft weighings. Increases should not be granted which would permit any aircraft to exceed 48 calendar months since last weighing. In the case of helicopters, increases should not exceed a time which is equivalent to the aircraft overhaul period.

e. Periodic weighing, aircraft using "fleet weights." Aircraft operating under fleet weights should be weighed in accordance with procedures outlined for the establishment of fleet weights. Since each fleet weight is normally reestablished every 3 years and a specified number of aircraft weighed at such periods, no additional weighing is considered necessary. A rotation program should, however, be incorporated so all aircraft in the fleet will be weighed periodically.

f. Weighing procedure. Normal precautions consistent with good practices in the weighing procedures, such as checking for completeness of the aircraft and equipment, determining that fluids are properly accounted for, and that weighing is accomplished in an enclosed building preventing the effect of the wind, should prevail. Any acceptable scales may be used for weighing provided they are properly calibrated, zeroed, and used in accordance with the manufacturer's instructions. Each scale should have been calibrated, either by the manufacturer or by a civil department of weights and measures, within 1 year prior to weighing any aircraft for this purpose unless the operator has evidence which warrants a longer period between calibrations.

8. LOADING SCHEDULE. Loading schedules should be simple and orderly, based on sound principles, thus reducing the element of human error. Loading schedules may be applied to individual aircraft or to a complete fleet. When an operator utilizes several types or models of aircraft, a loading schedule, which may be index-type, tabular-type, or a computer, should be identified with the type or model of aircraft for which it is designed.

9. LOADING PROVISIONS. All seats, compartments, and other loading stations should be properly marked and the identification used should correspond with the instructions established for computing the weight and balance of the aircraft. When the loading schedule provides for blocking off seats or compartments in order to remain within the center of gravity limits, effective means should be provided to assure that such seats or

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compartments are not occupied during operations specified. Instructions should be prepared for crewmembers, cargo handlers, and other personnel concerned giving complete necessary information regarding distribution of passengers, cargo, fuel, and other items. Information relative to maximum capacities and other pertinent limitations affecting the weight or balance of the aircraft should be included in these instructions. When it is possible by adverse distribution of passengers to exceed the approved CG limits of the aircraft, special instructions should be issued to the appropriate crewmembers so that the load distribution can be maintained within the approved limitation. A suitable commercial scale should be available for use when passenger, baggage, and cargo weights are otherwise undeterminable.

10. PASSENGER WEIGHTS. Actual or average passenger weights may be used to compute passenger loads over any segment of a certificate holder's operation except that actual weights should be used for operations with reciprocating powered aircraft of 9 or less seats, and for all operations involving nonstandard weight passenger groups. Both methods may be used interchangeably provided only one method is used for any flight from originating to terminating point; except as indicated in subparagraph b. The loading system should readily accommodate nonstandard weight groups and the manifest should indicate whether average or actual weights, or a combination thereof, were used in the computation.

a. Average passenger weight. The standard average passenger weights listed in the following table were derived from an extensive survey of conventional airline passenger groups. They should not be arbitrarily adopted for operations with passenger groups that appreciably differ from that basis. Special average weights may be established for particular operations based on surveys indicating those weights consistently provide for loading within prescribed weight and balance limits. Predominantly male passenger groups usually warrant higher averages.

STANDARD AVERAGE WEIGHTS

Adult Passenger	(Summer) - May 1 - October 31	160 pounds
Adult Passenger	(Winter) - November 1 - April 30	165 pounds
Children (age 2-12)		80 pounds

NOTE: Children under age 2 are considered "babes-in-arms" and children over age 12 should be treated as adult passengers for purposes of standard average weights.

b. Actual passenger weights. Actual passenger weights should be used in the case of flights carrying large groups of passengers whose average weight obviously does not conform with the normal standard weight such as athletic squads or other groups which are smaller or larger than the U.S. average. Where such a group forms only a part of the total passenger load, the actual weights may be used for such groups and average weights used for the balance of the passenger load. In such instances, a notation should be made on the load manifest indicating number of persons in the special group and identifying the group; i.e., football squad, Orly Titans, etc. Also, actual weights should be used for aircraft with small passenger capacities whereby deviations from average weights could result in exceeding weight and balance limits.

(1) Actual passenger weight may be determined by scale weighing of each passenger prior to boarding the aircraft, and such weight is to include minor articles carried on board by the passenger. If such articles are not weighed, the estimated weight should be accounted for.

(2) The actual passenger weight may also be determined by asking each passenger their weight and adding thereto a predetermined constant to provide for handcarried articles and also to cover possible seasonal effect upon passenger weight due to variance in clothing weight. This constant may be approved for an operator on the basis of studies by the operator that consider particular routes and seasonal variations, when applicable. Personnel manifesting passengers on this basis should be instructed on estimating passenger weights to reasonably confirm their accuracy.

(3) A weight range may be used in lieu of actual weights for small passenger capacity aircraft to facilitate a loading schedule. For example, all passengers whose actual weights are between 160 and 180 pounds are considered as 170-pound passengers for the schedule, manifest, etc., and the system should readily provide for passengers whose weights are outside the range.

11. CREW WEIGHT. For crewmembers, the following approved average weight may be utilized:

a. Male cabin attendants 150 pounds; female cabin attendants 130 pounds.

b. All other crewmembers 170 pounds.

12. PASSENGER AND CREW BAGGAGE. Procedures should be provided so that all baggage, including that carried on board by the passengers, is properly accounted for. If desired by the operator, a standard crew baggage weight may be used. Operators under Part 135 should use actual passenger baggage weights for reciprocating engine-powered aircraft type certificated for 9 or less passenger seats. The following average passenger baggage weights may be used in lieu of actual weights:

a. For operations under Part 135 with turbine-powered aircraft and/or aircraft type certificated for 10 or more passenger seats, an operator may establish average passenger baggage weights predicated on a study of actual baggage weights for the operations or routes involved that consider seasonal and other variables.

b. For domestic operations under Part 121.

(1) For each piece of checked baggage, an average of not less than 23.5 pounds; and

(2) For each passenger boarding the aircraft, an average of not less than 5 pounds is added for hand baggage whether or not such baggage is carried by the passenger.

c. For transatlantic flights between U.S. and Europe or transpacific flights via Manila, Tokyo, Hong Kong, or Australia by operators under Part 121.

(1) For each piece of checked baggage, an average of not less than 26.5 pounds.

(2) For each passenger boarding the aircraft not less than 5 pounds is added for hand baggage whether or not such baggage is carried by the passenger.

d. For transpacific flights originating and terminating at U.S., Honolulu, or Alaska by operators under Part 121.

(1) For each piece of checked baggage, an average of not less than 23.5 pounds; and

(2) For each passenger boarding the aircraft not less than 5 pounds is added for hand baggage whether or not such baggage is carried by the passenger.

e. Average passenger baggage weights shall not be used in computing the weight and balance of charter flights and other special services involving the carriage of special groups.

13. CENTER OF GRAVITY TRAVEL DURING FLIGHT. The operator should show that the procedures fully account for the extreme variation in center of gravity travel during flight caused by all or any combination of the following variables:

a. The movement of a number of passengers and cabin attendants equal to the placarded capacity of the lounges and lavatories from their normal position in the aircraft cabin to such lounge or lavatory. If the capacity of such compartment is one, the movement of either one passenger or one

cabin attendant, whichever most adversely affects the CG condition should be considered. When the capacity of the lavatory or lounge is two or more, the movement of that number of passengers or cabin attendants from positions evenly distributed throughout the aircraft may be used. Where seats are blocked off, and the movement of passengers and/or cabin attendants is evenly distributed throughout, only the actual loaded section of the aircraft should be used. The extreme movements of the cabin attendants carrying out their assigned duties within the cabin should be considered. The various conditions should be combined in such a manner that the most adverse effect on the CG will be obtained, and so accounted for, in the development of the loading schedule to assure the aircraft is being loaded within the approved limits at all times during flight.

b. Landing gear retraction. Possible change in CG position due to landing gear retraction should be investigated and results accounted for.

c. Fuel. The effect of the CG travel of the aircraft during flight, due to fuel used down to the required reserve fuel or to an acceptable minimum reserve fuel established by the operator, should be accounted for.

14. RECORD. The weight and balance system should include methods by which the operator will maintain a complete, current, and continuous record of the weight and center of gravity of each aircraft. Such records should reflect all alterations and changes affecting either the weight or balance of the aircraft, and will include a complete and current equipment list. When fleet weights are used, pertinent computations should also be available in individual aircraft files.

15. WEIGHT OF FLUIDS. The weight of all fluids used in aircraft may be established on the basis of actual weight, a standard volume conversion, or a volume conversion utilizing appropriate temperature correction factors to accurately determine the weight by computation of the quantity of fluid on board.

16. CONTENT OF OPERATIONS SPECIFICATIONS PROCEDURES FOR AIRCRAFT WEIGHT AND BALANCE CONTROL. The operations specifications should contain the procedures used to maintain control of weight and balance of all aircraft operated under the terms of the operating certificate which assures that the aircraft, under all operating conditions, is loaded within the gross weight and center of gravity limitations. This description should include a reference to the procedures used for determining weight of passengers/crew, weight of baggage, periodic aircraft weighing, type of loading devices, and identification of the aircraft concerned.


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