U.S. Department
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**Federal Aviation
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AC 120-27E

DATE: 6/10/05

ADVISORY CIRCULAR

AIRCRAFT WEIGHT
AND BALANCE CONTROL

Flight Standards Service
Washington, D.C.

Initiated By: AFS-200/AFS-300

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: AIRCRAFT WEIGHT AND BALANCE CONTROL

Date: 6/10/05
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AC No: 120-27E
Change:

1. What is the purpose of this advisory circular (AC)?

a. This AC provides operators with guidance on how to develop and receive approval for a weight and balance control program for aircraft operated under Title 14 of the Code of Federal Regulations (14 CFR) part 91, subpart K of part 91, and parts 121, 125, and 135.

b. This AC presents recommendations for an acceptable means, but not the only means, to develop and receive approval for a weight and balance control program, and includes guidance for using average and estimated weights in accordance with part 121, section 121.153(b) and other applicable parts of subpart K of part 91 and parts 121, 125, and 135.

NOTE: Per part 125, section 125.91(b), no person may operate an airplane in a part 125 operation unless the current empty weight and center of gravity (CG) are calculated from the values established by an actual weighing of the airplane within the preceding 36 calendar-months.

c. If an operator adopts the suggestions contained in this AC, the operator must ensure that, when appropriate, it replaces discretionary language such as “should” and “may” with mandatory language in relevant manuals, operations specifications (OpSpecs), or management specifications (MSpecs).

2. How is this AC organized?

This AC has three main chapters and six appendixes. Chapter 1 addresses aircraft weighing and loading schedules. Chapter 2 describes different methods to determine the weight of passengers and bags. Chapter 3 addresses the Federal Aviation Administration’s (FAA) role in developing and approving an operator’s weight and balance control program. Finally, Appendixes 1 through 6 contain technical information such as definitions, sources of data used in the AC, a sample loading envelope, an additional curtailment for passenger weight variation, suggestions to improve accuracy, and a checklist for operators.

3. What documents does this AC cancel?

This AC cancels AC 120-27D, *Aircraft Weight and Balance Control*, dated August 11, 2004.

4. What should an operator consider while reading this AC?

a. Accurately calculating an aircraft's weight and CG before flight is essential to comply with the certification limits established for the aircraft. These limits include both weight and CG limits. By complying with these limits and operating under the procedures established by the manufacturer, an operator is able to meet the weight and balance requirements specified in the aircraft flight manual (AFM). Typically, an operator calculates takeoff weight by adding the operational empty weight (OEW) of the aircraft, the weight of the passenger, cargo payload, and the weight of fuel. The objective is to calculate the takeoff weight and CG of an aircraft as accurately as possible.

b. When using average weights for passengers and bags, the operator must be vigilant to ensure that the weight and balance control program reflects the reality of aircraft loading. The FAA will periodically review the guidance in this AC and update this AC if average weights of the traveling public should change or if regulatory requirements for carry-on bags or personal items should change. Ultimately, the operator is responsible for determining if the procedures described in this AC are appropriate for use in its type of operation.

5. Who should use this AC?

a. This document provides guidance to both passenger and cargo operators that are either required to have an approved weight and balance control program under parts 121 and 125, or choose to use actual or average aircraft, passenger, or baggage weights when operating under part 91, subpart K of part 91, or part 135. The guidance in this AC is useful for anyone involved in developing or implementing a weight and balance control program.

b. As shown in Table 1, the FAA has divided aircraft into three categories for this AC to provide guidance appropriate to the size of the aircraft.

TABLE 1. AIRCRAFT CABIN SIZE

For this AC, an aircraft originally type-certificated with—	**Is considered—**
71 or more passenger seats	A large-cabin aircraft.
30 to 70 passenger seats	A medium-cabin aircraft.
5 to 29 passenger seats	A small-cabin aircraft.

NOTE: Aircraft with fewer than five passenger seats must use actual passenger and baggage weights.

6. Who can use standard average or segmented weights?

a. Standard Average Weights. Use of standard average weights is limited to operators of multiengine turbine-powered aircraft originally type-certificated for five or more passenger seats who hold a letter of authorization (LOA), OpSpecs, or MSpecs, as applicable, and were certificated under 14 CFR part 25, 29, or part 23 commuter category or the operator and manufacturer is able to prove that the aircraft can meet the performance requirements prescribed by part 23 commuter category aircraft. Single-engine and multiengine turbine Emergency Medical Service Helicopter (EMS/H) operators may use standard average weights for EMS operations, provided they have received an LOA.

b. Segmented Weights. Segmented weights are provided for, but not limited to those aircraft that are multiengine turbine-powered aircraft originally type-certificated for five or more passenger seats and that do not meet the performance requirements of part 23 commuter category aircraft or part 29. Segmented passenger weights are listed in Chapter 2, Table 2-5.

c. The FAA's recommendations and advice on the safe use of standard average weights and segmented weights are contained in this document. In the FAA's view, it would be unsafe for an aircraft operator to use standard average weights or segmented weights in any of the following aircraft:

(1) All single-engine piston-powered aircraft.

(2) All multiengine piston-powered aircraft.

(3) All turbine-powered single-engine aircraft.

NOTE: All multiengine turbine-powered aircraft certificated under part 23, except for commuter category aircraft, may only use an actual weight or segmented weight program. Operators that elect to use a segmented weight program must meet the requirements in paragraph 6b and curtail the CG envelope as specified in Appendix 3, 4, and 5. Commuter category aircraft may use standard average weights and should refer to paragraph 200f for further guidance.

7. When will the FAA revise the standard average weights in this AC?

The FAA will periodically review the standard average passenger weights listed in this AC, after the release of a new National Health and Nutrition Examination Survey (NHANES). (For information on NHANES, see Appendix 2.) If the FAA finds that the data from NHANES indicates a weight change of more than 2 percent, the FAA will revise this AC to update the standard average weights.

/s/ John M. Allen for
James J. Ballough
Director, Flight Standards Service

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CHAPTER 1. AIRCRAFT WEIGHTS AND LOADING SCHEDULES

Section 1. Establishing Aircraft Weight

100. How does an operator establish the initial weight of an aircraft?

Prior to being placed into service, each aircraft should be weighed and the empty weight and CG 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 were adjusted for alterations and modifications to the aircraft unless some other modification to the aircraft warrants that the aircraft be weighed (e.g., paragraph 103c). Aircraft transferred from one operator that has an approved weight and balance program, to another operator with an approved program, does not need to be weighed prior to use by the receiving operator unless more than 36 calendar-months have elapsed since last individual or fleet weighing, or unless some other modification to the aircraft warrants that the aircraft be weighed (e.g., paragraph 103c). Aircraft transferred, purchased, or leased from an operator without an approved weight and balance program, and that have been unmodified or only minimally modified, can be placed into service without being reweighed if the last weighing was accomplished by an acceptable method (for example, manufacturer's instructions or AC 43.13-1, Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair, current edition) within the last 12 calendar-months and a weight and balance change record was maintained by the operator. See paragraph 103c for a discussion of when it may be potentially unsafe to fail to reweigh an aircraft after it has been modified.

101. How does an operator document changes to an aircraft's weight and balance?

The weight and balance system should include methods, such as a log, ledger, or other equivalent electronic means, by which the operator will maintain a complete, current, and continuous record of the weight and CG of each aircraft. Alterations and changes affecting either the weight and/or balance of the aircraft should be recorded in this log. Changes in the amount of weight or in the location of weight in or on the aircraft should be recorded whenever the weight change is at or exceeds the weights listed in Table 1-1.

TABLE 1-1. INCREMENTAL WEIGHT CHANGES THAT SHOULD BE RECORDED IN A WEIGHT AND BALANCE CHANGE RECORD

In the weight change record of a—	An operator should record any weight changes of—
Large-cabin aircraft	+/- 10 lb or greater.
Medium-cabin aircraft	+/- 5 lb or greater.
Small-cabin aircraft	+/- 1 lb or greater.

102. How does the operator maintain the OEW?

The loading schedule may utilize the individual weight of the aircraft in computing operational weight and balance, or the operator may choose to establish fleet empty weights for a fleet or group of aircraft.

a. Reestablishment of OEW. The OEW and CG position of each aircraft should be reestablished at the reweighing periods discussed in paragraph 103. In addition, it should be reestablished through calculation whenever the cumulative change to the weight and balance log is more than plus or minus one-half of 1 percent (0.5 percent) of the maximum landing weight, or whenever the cumulative change in the CG position exceeds one-half of 1 percent (0.5 percent) of the mean aerodynamic chord (MAC). In the case of helicopters and airplanes that do not have a MAC-based CG envelope (e.g., canard equipped airplane), whenever the cumulative change in the CG position exceeds one-half of 1 percent (0.5 percent) of the total CG range, the weight and balance should be reestablished.

NOTE: When reestablishing the aircraft OEW between reweighing periods, the weight changes may be computed provided the weight and CG location of the modifications are known; otherwise the aircraft must be reweighed.

b. Fleet Operating Empty Weights (FOEW). An operator may choose to use one weight for a fleet or group of aircraft if the weight and CG of each aircraft is within the limits stated above for establishment of OEW. When the cumulative changes to an aircraft weight and balance log exceed the weight or CG limits for the established fleet weight, the empty weight for that aircraft should be reestablished. This may be done by moving the aircraft to another group, or reestablishing new FOEWs.

103. How often are aircraft weighed?

a. Individual Aircraft Weighing Program. Aircraft 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 preceding period of operation show that weight and balance records accurately reflect aircraft weights and CG positions are within the cumulative limits specified for establishment of OEW (see paragraph 102). Under an individual aircraft weighing program, an increase should not be granted which would permit any aircraft to exceed 48 calendar-months since the last weighing, including when an aircraft is transferred from one operator to another. In the case of helicopters, increases should not exceed a time that is equivalent to the aircraft overhaul period.

NOTE: Per section 125.91(b), no person may operate an airplane in a part 125 operation, unless the current empty weight and CG are calculated from the values established by an actual weighing of the airplane within the preceding 36 calendar-months.

b. Fleet Weighing. An operator may choose to weigh only a portion of the fleet every 36 months and apply the weight and moment change determined by these sample weighings to the remainder of the fleet. For each aircraft weighed, the new aircraft empty weight (and moment) is determined by the weighing and entered in the aircraft weight log. The difference between this new aircraft weight (and moment) and the previous aircraft weight (and moment) shown in the log is the unaccounted weight (and moment) change. The average of the unaccounted weight and moment changes for the aircraft weighed as part of this fleet weighing is then entered as an adjustment to the aircraft weight logs for each of the aircraft in the fleet that were not weighed.

(1) A fleet is composed of a number of aircraft of the same model. (For example, B747-200s in a passenger configuration and B747-200 freighters should be considered different fleets. Likewise, B757-200s and B757-300s should be considered different fleets.) The primary purpose of defining a fleet is to determine how many aircraft should be weighed in each weighing cycle. A fleet may be further divided into groups to establish FOEWs.

TABLE 1-2. NUMBER OF AIRCRAFT TO WEIGH IN A FLEET

For fleets of—	An operator must weigh (at minimum)—
1 to 3 aircraft	All aircraft.
4 to 9 aircraft	3 aircraft, plus at least 50 percent of the number of aircraft greater than 3.
More than 9 aircraft	6 aircraft, plus at least 10 percent of the number of aircraft greater than 9.

(2) In choosing the aircraft to be weighed, the aircraft in the fleet having the most hours flown since last weighing should be selected.

(3) An operator should establish a time limit such that all aircraft in a fleet are eventually weighed. Based on the length of time that a fleet of aircraft typically remains in service with an operator, the time limit should not exceed 18 years (six 3-year weighing cycles). It is not intended that an operator be required to weigh any remaining aircraft in the event that business conditions result in retirement of a fleet before all aircraft have been weighed.

c. Weighing Aircraft—Modifications. For most aircraft modifications, computing the weight and balance changes is practical. For some modifications, such as interior reconfigurations, the large number of parts removed, replaced, and installed may make an accurate determination of the weight and balance change by computation impractical.

1. In those instances when the accuracy of the calculation is questionable, the weight and moment change estimate should be verified by reweighing the aircraft. The operator should weigh two or more aircraft to confirm the computed weight change estimate. The operator may choose to weigh the aircraft before and after the modification, or just after the modification. If the weighings are inconsistent with the computed weight change estimate, then additional aircraft should be weighed as prescribed in Table 1-2, based on the size of the fleet.

2. The operator may choose not to calculate the weight change but to reestablish the aircraft weight and balance by reweighing the aircraft prior to subsequent revenue operation. An operator using an *individual* aircraft weighing program would weigh each aircraft modified, and an operator using a *fleet* weighing program would weigh the number of aircraft as prescribed in Table 1-2, based on the size of the fleet.

104. What procedures should be used to weigh aircraft?

a. An operator should take precautions to ensure that it weighs an aircraft as accurately as possible. These precautions include checking to ensure that all required items are aboard the aircraft and the quantity of all fluids aboard the aircraft is considered. An operator should weigh the aircraft in still air.

b. An operator should establish and follow instructions for weighing the aircraft that are consistent with the recommendations of the aircraft manufacturer and scale manufacturer. The operator should ensure that all scales are certified and calibrated by the manufacturer or a certified laboratory, such as a civil department of weights and measures, or the operator may calibrate the scale under an approved calibration program. The operator should also ensure that the scale is calibrated within the manufacturer's recommended time period, or time periods, as specified in the operator's approved calibration program.

NOTE: If manufacturer's data is not available, the operator is responsible for developing appropriate weighing instructions for its particular aircraft.

Section 2. Aircraft Loading Schedules

105. What is a loading schedule?

a. The loading schedule is used to document compliance with the certificated weight and balance limitations contained in the manufacturer's AFM and weight and balance manual.

b. The loading schedule is developed by the operator based on its specific loading calculation procedures and provides the operational limits for use with the operator's weight and balance program approved under this AC. These approved operational limits are typically more restrictive but may not exceed the manufacturer's certificated limits. This is because the loading schedule is generally designed to check only specific conditions (e.g., takeoff and zero fuel) known prior to takeoff, and must account for variations in weight and balance in flight. It must also account for factors selected to be excluded, for ease of use, from the calculation process. Loading the aircraft so that the calculated weight and balance is within the approved limits will maintain the actual weight and balance within the certificated limits throughout the flight.

c. Development of a loading schedule represents a trade-off between ease of use and loading flexibility. A schedule can provide more loading flexibility by requiring more detailed inputs, or it can be made easier to use by further limiting the operational limits to account for the uncertainty caused by the less detailed inputs.

d. Several types of loading schedules are commonlyused, including computer programs as well as "paper" schedules, which can be either graphical, such as an alignment ("chase around chart") system, slide rule, or numerical, such as an adjusted weight or index system.

e. It is often more convenient to compute the balance effects of combined loads and to display the results by using "balance units" or "index units." This is done by adding the respective moments (weight times arm) of each item. Graphing the moments results in a "fan grid" where lines of constant balance arms (BA) or percent MAC are closer together at lower weights and further apart at higher weights. Direct graphical or numerical addition of the balance effects are possible using these moment values.

f. To make the magnitude of the numbers more manageable, moments can be converted to an index unit. For example:

$$index\ unit = \frac{weight \times (BA - datum)}{M} + K$$

> **NOTE: Where *datum* is the reference BA that will plot as a vertical line on the fan grid, *M* and *K* are constants that are selected by the operator. *M* is used to scale the index values, and *K* is used to set the index value of the reference BA.**

106. How should an operator determine the weight of each fluid used aboard the aircraft?

An operator should use one of the following:

a. The actual weight of each fluid,

b. A standard volume conversion for each fluid, or

c. A volume conversion that includes a correction factor for temperature.

Section 3. Constructing a Loading Envelope

107. What should an operator consider when constructing a loading envelope?

Each operator complying with this AC must construct a “loading envelope” applicable to each aircraft being operated. The envelope will include all relevant weight and balance limitations. It will be used to ensure that the aircraft is always operated within appropriate weight and balance limitations, and will include provisions to account for the loading of passengers, fuel, and cargo; the in-flight movement of passengers, aircraft components, and other loaded items; and the usage or transfer of fuel and other consumables. The operator must be able to demonstrate that the aircraft is being operated within its certificated weight and balance limitations using reasonable assumptions that are clearly stated.

108. What information from the aircraft manufacturer should an operator use?

The construction of the loading envelope will begin with the weight and balance limitations provided by the aircraft manufacturer in the weight and balance manual, type certificate data sheet, or similar approved document. These limitations will include, at minimum, the following items, as applicable:

a. Maximum zero-fuel weight.

b. Maximum takeoff weight.

c. Maximum taxi weight.

d. Takeoff and landing CG limitations.

e. In-flight CG limitations.

f. Maximum floor loadings—including both running and per square foot limitations.

g. Maximum compartment weights.

h. Fuselage shear limitations.

i. Any other limitations provided by the manufacturer.

109. What should the operator consider when curtailing the manufacturer’s loading envelope?

a. The operator should curtail the manufacturer’s loading limitations to account for loading variations and in-flight movement that are encountered in normal operations. For example, if passengers are expected to move about the cabin in flight, the operator must curtail the manufacturer’s CG envelope by an amount necessary to ensure that movement of passengers does not take the aircraft outside its certified envelope. If the aircraft is loaded within the new, curtailed envelope, it will always be operated within the manufacturer’s envelope, even though some of the loading parameters, such as passenger seating location, are not precisely known.

b. In some cases an aircraft may have more than one loading envelope for preflight planning and loading. Each envelope must have the appropriate curtailments applied for those variables that are expected to be relevant for that envelope. For example, an aircraft might have separate takeoff, in-flight, and landing envelopes. Passengers are expected to remain seated in the cabin during take-off or landing. Therefore, the takeoff and landing envelope does not need to be curtailed for passenger movement.

c. Upon determination of the curtailed version of each envelope, the most restrictive points (for each condition the operator's program will check) generated by an "overlay" of the envelopes will form the aircraft operational envelopes. These envelopes must be observed. By restricting operation to these "operational envelopes," compliance with the manufacturer's certified envelope will be ensured in all phases of flight, based upon the assumptions within the curtailment process. Optionally, an operator may choose to not combine the envelopes but observe each envelope independently. However, due to calculation complexity, this is typically only possible through automation of the weight and balance calculation.

110. What are some examples of common curtailments to the manufacturer's loading envelope?

The following subparagraphs provide "examples" of common loading curtailments. Appendix 3 also provides an example of how these curtailments are calculated. Operators using an approved weight and balance control program must include curtailments appropriate to the operations being conducted. Each of the items mentioned below is a single curtailment factor. The total curtailment of the manufacturer's envelope is computed by combining the curtailments resulting from each of these factors.

a. Passengers. The operator must account for the seating of passengers in the cabin. The loading envelope does not need to be curtailed if the actual seating location of each passenger is known. If assigned seating is used to determine passenger location, the operator must implement procedures to ensure that the assignment of passenger seating is incorporated into the loading procedure. It is recommended that the operator take into account the possibility that some passengers may not sit in their assigned seats.

(1) If the actual seating location of each passenger is not known, the operator may assume that all passengers are seated uniformly throughout the cabin or a specified subsection of the cabin. If this assumption is made, the operator must curtail the loading envelope to account for the fact that the passenger loading may not be uniform. The curtailment may make reasonable assumptions about the manner in which people distribute themselves throughout the cabin. For example, the operator may assume that window seats are occupied first, followed by aisle seats, followed by the remaining seats (window-aisle-remaining seating). Both forward and rear loading conditions should be considered. That is, the passengers may fill up the window, aisle, and remaining seats from the front of the aircraft to the back, or the back to the front.

(2) If necessary, the operator may divide the passenger cabin into subsections or "zones" and manage the loading of each zone individually. It can be assumed that passengers will be sitting uniformly throughout each zone, as long as the curtailments described in the previous paragraph are put in place.

(3) All such assumptions should be adequately documented.

b. Fuel. The operator's curtailed loading envelope must account for the effects of fuel. The following are examples of several types of fuel-related curtailments:

(1) Fuel density. A certain fuel density may be assumed and a curtailment included to account for the possibility of different fuel density values. Fuel density curtailments only pertain to differences in fuel moment caused by varying fuel volumes, not to differences in total fuel weight. The fuel gauges in most transport category aircraft measure weight, not volume. Therefore, the indicated weight of the fuel load can be assumed to be accurate.

(2) Fuel movement. The movement or transfer of fuel in flight.

(3) Fuel usage in flight. The burning of fuel may cause the CG of the fuel load to change. The effect of fuel burning down to the required reserve fuel or to an acceptable fuel amount established by the operator should be accounted for. A curtailment may be included to ensure that this change does not cause the CG of the aircraft to move outside of the acceptable envelope.

c. Fluids. The operator's curtailed CG envelope must account for the effects of galley and lavatory fluids. These factors include such things as:

(1) Use of potable water in flight.

(2) Movement of water or lavatory fluids.

d. In-Flight Movement of Passenger and Crew. The operational envelope must account for the in-flight movement of passengers, crew, and equipment. This may be done by including a curtailment equal to the moment change caused by the motion being considered. It may be assumed that all passengers, crew, and equipment are secured when the aircraft is in the takeoff or landing configuration. Standard operational procedures may be taken into account. Examples of items that can move during flight are:

(1) Flight deck crewmembers moving to the lavatory. Flight deck crewmembers may move to the most forward lavatory in accordance with the security procedures prescribed for crews leaving the cockpit. An offsetting credit may be taken if another crewmember moves to the flight deck during such lavatory trip.

(2) Flight attendants moving throughout the cabin. Operators should take their standard operating procedures into account. If procedures do not dictate otherwise, it should be assumed that the flight attendants can travel anywhere within the compartment to which they are assigned.

(3) Service carts moving throughout the cabin. Operators should take their standard operating procedures into account. If procedures do not dictate otherwise, it should be assumed that the service carts can travel anywhere within the compartment to which they are assigned. If multiple carts are in a given compartment, and no restrictions are placed on their movement, then the maximum number of carts, moving the maximum distance, must be considered. The weight of the number of flight attendants assigned to each cart must also be considered. The assumed weight of each cart may be the maximum anticipated cart-load or the maximum design load, as appropriate to the operator's procedures.

(4) Passengers moving throughout the cabin. Allowances should be made for the possibility that passengers may move about the cabin in flight. The most common would be movement to the lavatory, described below. If a lounge or other passenger gathering area is provided, the operator should assume that passengers move there from the centroid of the passenger cabin(s). The maximum capacity of the lounge should be taken into account.

(5) Passengers moving to the lavatory. Operators should account for the CG change caused by passengers moving to the lavatory. Operators should develop reasonable scenarios for the movement of passengers in their cabins and consider the CG shifts that can be expected to occur. Generally, it may be assumed that passengers move to the lavatories closest to their seats. In aircraft with a single lavatory, movement from the "most adverse" seat must be taken into account. Assumptions may be made which reflect operator lavatory and seating policies. For example, it may be assumed that coach passengers may only use the lavatories in the coach cabin, if that is the operator's normal policy.

e. Movement of Flaps and Landing Gear. If the manufacturer has not already done so, the operator must account for the movement of landing gear, flaps, wing leading edge devices, or any other moveable components of the aircraft. Devices deployed only while in contact with the ground, such as ground spoilers or thrust reversers, may be excluded from such curtailments.

f. Baggage and Freight. It can be assumed that baggage and freight may be loaded at the centroid of each baggage compartment. Operators do not need to include a curtailment if procedures are used which ensure that the cargo is loaded uniformly and physically restrained (secured) to prevent the contents from becoming a hazard by shifting between zones or compartments.

Section 4. Onboard Weight and Balance Systems

111. How does an onboard weight and balance system compare to a conventional weight buildup method?

a. An operator may use an onboard weight and balance system to measure an aircraft's weight and balance as a primary means to dispatch an aircraft, provided the FAA has certified the system, and approved the system for use in an operator's weight and balance control program. This section discusses the differences an operator should consider when using an onboard weight and balance system compared to a conventional weight buildup method. This section addresses only the operational considerations related to the use of an FAA-authorized onboard weight and balance system.

b. Like operators using a conventional weight buildup method to calculate weight and balance, an operator using an onboard weight and balance system as a primary weight and balance control system should curtail the manufacturer's loading envelope to ensure the aircraft does not exceed the manufacturer's certificated weight and CG limits. However, an operator using an onboard weight and balance system would not need to curtail the loading envelope for assumptions about passenger and bag weight or distribution.

c. Because an onboard weight and balance system measures the actual weight and CG location of an aircraft, an operator may not need to include certain curtailments to the loading envelope to account for variables such as passenger seating variation or variation in passenger weight. However, an operator should curtail the loading envelope for any system tolerances that may result in CG errors. Using an onboard weight and balance system does not relieve an operator from the requirement to complete and maintain a load manifest.

112. What measures should an operator take to obtain operational approval for an onboard weight and balance system?

a. System Calibration. An operator should develop procedures to calibrate its onboard weight and balance system equipment periodically in accordance with the manufacturer's instructions. An operator may calibrate its system with operational items or fuel aboard the aircraft to test the system at a representative operational weight. However, an operator may not use an onboard weight and balance system in place of procedures described in Section 1 of this chapter for weighing the aircraft to establish OEW or CG location.

b. Demonstration of System Accuracy. As part of the approval process, an operator should demonstrate that the onboard weight and balance system maintains its certificated accuracy. An operator should only have to conduct this demonstration once for each type aircraft with a similarly installed onboard weight and balance system. For the demonstration, the operator should use the accuracy demonstration test provided in the maintenance manual portion of the Supplemental Type Certificate or type certificate of the onboard weight and balance system.

113. What operational considerations should an operator take into account when using an onboard weight and balance system?

a. Certification Limits. An operator using an onboard weight and balance system as its primary means of calculating weight and balance should have procedures in place to ensure that the system is operated within the limits established during the system's certification process.

b. Environmental Considerations. An operator using an onboard weight and balance system should ensure that it uses the system within the environmental limits established by the manufacturer. Environmental conditions that may affect the performance of an onboard weight and balance system include temperature, barometric pressure, wind, ramp slope, rain, snow, ice, frost, dew, deicing fluid, etc.

c. Aircraft Considerations. An operator using an onboard weight and balance system should ensure the weight and CG measured by the system are not affected by the aircraft configuration, such as the movement of flaps, stabilizers, doors, stairways or jetways, or any connections to ground service equipment. Other factors that an operator should consider include engine thrust, oleo strut extension, and aircraft taxi movement.

d. Takeoff Trim Settings. If the aircraft manufacturer provides trim settings for takeoff based on the aircraft's CG location, an operator using an onboard weight and balance system should ensure that the onboard weight and balance system provides flight crewmembers with adequate information to determine the appropriate trim setting.

e. Operational Envelope. The operational envelope for onboard weight and balance systems should be developed using the same procedures described in other parts of this AC, with the exception that the operational envelope does not need to be curtailed for passenger random seating and passenger weight variance. Also note that the fuel load is subtracted from the measured takeoff weight to determine the zero fuel weight and CG, instead of being added to the zero fuel weight as part of the load buildup. In addition, an operator should curtail the CG envelope for any system CG tolerance.

f. Complying with Compartment or Unit Load Device (ULD) Load Limits. When using an onboard weight and balance system, an operator should develop in its weight and balance control program a method to ensure that it does not exceed the floor, linear or running loading limits specified for a compartment or ULD. If an operator develops appropriate procedures, an operator may request approval to exclude bag counts from its load manifest. The following are two examples of acceptable means to demonstrate compliance with compartment load limits.

(1) An operator may assign a standard average weight to bags. Based on that standard average weight, the operator may place a placard in each compartment stating the maximum number of bags permitted. An operator may also create a table that lists the total weight associated with a given number of bags to ensure the operator does not exceed the load limit of a compartment or ULD.

(2) By conducting sample loadings, an operator may demonstrate that the average density of the bags it places in a compartment or ULD would not allow it to exceed the compartment or ULD load limits inadvertently.

114. May an operator use the information in this AC to develop a backup system?

An operator using an onboard weight and balance system as its primary means of measuring weight and balance may use the guidance in this AC to develop a backup system based on a conventional weight buildup provided that the backup system has been approved by the certificate-holding district office/Flight Standards District Office. Should the primary onboard weight and balance system become inoperative, the operator must have provisions for deferring the inoperative equipment until repairs can be made or the system must be repaired prior to further flight. The FAA may grant the operator relief for an onboard weight and balance system through the operator's minimum equipment list (MEL). Such MEL relief will be established through a global change policy letter issued by AFS-200 upon certification of an onboard weight and balance system. An operator using an onboard weight and balance system may not use the backup system unless:

a. The onboard system is inoperative;

b. The onboard system has been deferred in accordance with the aircraft MEL; and

c. The operator has been approved to use average weights/conventional weight buildup.

CHAPTER 2. METHODS TO DETERMINE THE WEIGHT OF PASSENGERS AND BAGS

Section 1. Choosing the Appropriate Method

200. What should an operator consider when choosing the appropriate method?

a. For many years, operators of transport category aircraft have used average weights for passengers and bags to calculate an aircraft's weight and balance, in accordance with standards and recommended practices. This method eliminates many potential sources of error associated with accounting for a large number of relatively light weights. However, differences between the actual weight of passengers and bags and the average weight of passengers and bags can occur when using average weights.

b. Statistical probability dictates that the smaller the sample size (i.e., cabin size), the more the average of the sample will deviate from the average of the larger universe. Because of this, the use of standard average passenger weights in weight and balance programs for small and medium cabin aircraft should be examined in greater detail.

c. The next four sections describe four methods available to operators to determine passenger and bag weight. They are standard average weights in Section 2; average weights based on survey results in Section 3; segmented weights in Section 4; and actual weights in Section 5. An operator should review the following discussion and consult Table 2-1 to determine which method or methods are appropriate to its type of operation.

d. Large Cabin Aircraft. Operators of large cabin aircraft may use the standard average weights for passengers and bags. If an operator determines that the standard average weights are not representative of its operation for some route or regions, it is encouraged to conduct a survey as detailed in Section 3 of this chapter, to establish more appropriate average weights for its operation. Operators should have procedures for identifying situations that would require the use of nonstandard or actual weights.

e. Medium Cabin Aircraft. Medium cabin aircraft should be evaluated to determine if the aircraft should be treated more like large or small cabin aircraft. For the FAA to recommend that medium cabin aircraft be treated as a large cabin aircraft, the aircraft must meet either (1) both loadability criteria, or (2) the loading schedule criteria. If the aircraft does not meet either of these criteria, then the FAA does not recommend that the operator be allowed to use large cabin aircraft measures. Instead, the aircraft should be subject to the small cabin aircraft methods outlined in paragraph 200f.

(1) Loadability criteria.

- The CG of the OEW is within the manufacturer's loading envelope
- The CG of the zero fuel weight is within the manufacturer's loading envelope when loaded with a full load of passengers and all cargo compartments are filled with a density of 10 pounds per cubic foot

(2) Loading schedule criteria.

- The operator must use a loading schedule based upon zones
- The aircraft cabin may have no more than four rows of seats per zone with not less than four zones

f. Small Cabin Aircraft. Operators of small cabin aircraft may request approval to use any one of the following methods when calculating the aircraft weight and balance.

(1) The operator may use actual passenger and bag weights, or

(2) The operator may use segmented passenger weights (see Section 4) and bag weights prescribed for large cabin aircraft, or

(3) The operator may use the standard average passenger and bag weights prescribed for large cabin aircraft or average weights based on an FAA-accepted survey if—

(a) The aircraft was certificated under part 23 commuter category, part 25, or part 29 (or is able to prove the aircraft has equivalent part 23 commuter category or part 29 performance data), and

(b) The operator applies the additional curtailments as prescribed in Appendix 4.

Section 2. Standard Average Weights

201. What standard average passenger weights should an operator use with an approved carry-on bag program?

a. The standard average passenger weights provided in Table 2-1 were established based on data from U.S. Government health agency surveys. For more background information on the source of these weights, refer to Appendix 2.

b. The standard average passenger weights in Table 2-1 include 5 pounds for summer clothing, 10 pounds for winter clothing, and a 16-pound allowance for personal items and carry-on bags. Where no gender is given, the standard average passenger weights are based on the assumption that 50 percent of passengers are male and 50 percent of passengers are female.

TABLE 2-1. STANDARD AVERAGE PASSENGER WEIGHTS

Standard Average Passenger Weight	Weight Per Passenger
Summer Weights	
Average adult passenger weight	190 lb
Average adult male passenger weight	200 lb
Average adult female passenger weight	179 lb
Child weight (2 years to less than 13 years of age)	82 lb
Winter Weights	
Average adult passenger weight	195 lb
Average adult male passenger weight	205 lb
Average adult female passenger weight	184 lb
Child weight (2 years to less than 13 years of age)	87 lb

c. An operator may use summer weights from May 1 to October 31 and winter weights from November 1 to April 30. However, these dates may not be appropriate for all routes or operators. For routes with no seasonal variation, an operator may use the average weights appropriate to the climate. Use of year-round average weights for operators with seasonal variation should avoid using an average weight that falls between the summer and winter average weights. Operators with seasonal variation that elect to use a year-round average weight should use the winter average weight. Use of seasonal dates, other than those listed above, will be entered as nonstandard text and approved through the operator's OpSpec, MSpec, or LOA, as applicable.

d. The standard average weights listed in Table 2-1 are based on the assumption that the operator has a carry-on bag program. Operators using a no-carry-on bag program should refer to paragraph 205 of this section.

NOTE: The weight of children under the age of 2 has been factored into the standard average and segmented adult passenger weights.

202. What standard average weights should an operator use for carry-on bags and personal items?

a. An operator using standard average passenger weights should include the weight of carry-on bags and personal items in the passenger's weight. The standard average passenger weights in Table 2-1 include a 16-pound allowance for personal items and carry-on bags, based on the assumption that—

(1) One-third of passengers carry one personal item and one carry-on bag.

(2) One-third of passengers carry one personal item or carry-on bag.

(3) One-third of passengers carry neither a personal item nor a carry-on bag.

(4) The average weight allowance of a personal item or a carry-on bag is 16 pounds.

b. If an operator believes the 16-pound allowance for personal items and carry-on bags is not appropriate for its operations or receives notification from the FAA that the assumptions provided in paragraph 202a are inconsistent with the operator's approved program, the operator should conduct a survey to determine what percentage of passengers carry personal items or carry-on bags aboard the aircraft. An example of how to adjust the personal item and carry-on bag allowance, based on the results of a survey, is in Section 3. An operator should not use an allowance of less than 16 pounds for personal items and carry-on bags unless the operator conducts a survey or unless the operator has a no-carry-on bag program.

NOTE: Operators using an approved carry-on baggage program should refer to AC 121-29, Carry-On Baggage, current edition, for information regarding carry-on baggage.

203. What standard average weights should an operator use for checked bags?

An operator that chooses to use standard average weights for checked bags should use a standard average weight of at least 30 pounds. An operator that requests approval to use a standard average weight of less than 30 pounds for checked bags should have current, valid survey data to support a lesser weight. An operator also may conduct a study to establish different standard average bag weights for portions of its operation to account for regional, seasonal, demographic, aircraft, or route variation. For example, an operator could establish different standard average bag weights for domestic and international routes.

a. Heavy Bags. Heavy bags are considered any bag that weighs more than 50 pounds but less than 100 pounds. An operator should account for a heavy bag by using one of the following weights:

(1) A standard average weight of 60 pounds,

(2) An average weight based on the results of a survey of heavy bags, or

(3) The actual weight of the heavy bag.

NOTE: An operator that uses "double-counting" to treat a heavy bag as if it were two checked bags for weight purposes should ensure the load manifest represents the actual number of bags for counting purposes. An operator should have a system in place to ensure that heavy bags are identified, although operators may not be required to weigh heavy bags on a scale.

b. Non-luggage Bags. A non-luggage bag is any bag that does not meet the normal criteria for luggage. Examples include golf bags, fishing equipment packages, wheelchairs and strollers in their shipping configuration, windsurfing kits, boxed bicycles, etc. For non-luggage bags, operators may use any appropriate combination of actual weights, average weights based on survey results, or standard average bag weights. Operators that wish to establish an average weight for a particular type of non-luggage bag, such as a golf bag, must conduct a survey in accordance with the procedures established in Section 3 of this chapter. Operators also should establish a method to calculate the effect on CG of a large non-luggage bag, such as a surfboard, that may occupy more than one compartment on the aircraft.

c. Plane-Side Loaded and Checked Bags. Part 91, subpart K of part 91, and part 135 on-demand operations using standard average bag weights should consider all bags not stored in the cabin as checked bags. However, operators may develop procedures for identifying bags that would typically be considered carry-on and/or plane-side loaded baggage and incorporate such average weights into their approved carry-on and weight and balance control program. If such procedures are developed, the operator may use the standard average weights specified for carry-on, plane-side loaded, and checked baggage. Operators conducting flights under parts 91 and 135 in which all passenger bags are typically loaded plane-side or all bags are carried into the cabin for further storage, should develop guidelines to inform pilots when it is appropriate to use the heavier standard average checked bag weights, heavy bag weights, or actual weights. In no case should an operator only use plane-side loaded standard average weights for all baggage loaded plane-side.

204. What standard average weight should an operator of large cabin aircraft use for bags checked plane-side?

Operators with a carry-on bag program that use standard average weights should account for the weight of each carry-on bag checked plane-side as 30 pounds. An operator may request approval to use a weight other than 30 pounds if the operator has current, valid survey data to support a different average weight for plane-side loaded bags.

205. What standard average weights should an operator of small and medium cabin aircraft use, if it has a "no-carry-on bag program?"

NOTE: A no-carry-on bag program is limited to small and medium cabin aircraft (including medium cabin aircraft treated as a large cabin aircraft). Associated with this program are certain standard average weight credits and reductions. Nothing in this AC prevents an operator of large cabin aircraft from having a no-carry-on bag "policy;" however, the acceptable standard bag weights for such checked baggage for large cabin aircraft are outlined in paragraphs 203 and 204 above. Furthermore, the passenger weight credit

associated with a no-carry-on-bag program is limited to the small and medium cabin aircraft.

a. An operator with a no-carry-on bag program may allow passengers to carry only personal items aboard the aircraft. Because these passengers do not have carry-on bags, an operator may use standard average passenger weights that are 6 pounds lighter than those for an operator with an approved carry-on bag program. See Table 2-2.

TABLE 2-2. AVERAGE PASSENGER WEIGHTS FOR OPERATORS WITH A NO-CARRY-ON BAG PROGRAM

Average Passenger Weight	Weight Per Passenger
Summer Weights	
Average passenger weight	184 lb
Average male passenger weight	194 lb
Average female passenger weight	173 lb
Child weight (2 years to less than 13 years of age)	76 lb
Winter Weights	
Average passenger weight	189 lb
Average male passenger weight	199 lb
Average female passenger weight	178 lb
Child weight (2 years to less than 13 years of age)	81 lb

b. An operator that has a no-carry-on bag program may account for a plane-side loaded bag as 20 pounds. To receive authorization to use 20 pounds as the average weight for a plane-side loaded bag, an operator should demonstrate that sufficient controls exist to ensure that passengers do not bring carry-on bags aboard the aircraft. An operator also should demonstrate that sufficient controls exist to ensure the personal items brought aboard the aircraft can fit completely under a passenger seat or in an approved stowage compartment.

c. If an operator discovers that a plane-side loaded bag should have been treated as a checked bag, the operator should account for that bag at the standard average weight of 30 pounds for a checked bag.

NOTE: Part 91, subpart K of part 91, and on-demand operations using standard average bag weights should consider all bags not stored in the cabin as checked bags (reference paragraph 203) unless the operator develops procedures for identifying bags that would typically be considered carry-on/plane-side loaded and/or traditional checked baggage.

206. What are the standard average weights for crewmembers?

a. An operator may choose to use the standard crewmember weights shown in Table 2-3 or conduct a survey to establish average crewmember weights appropriate for its operation.

TABLE 2-3. STANDARD CREWMEMBER WEIGHTS

Crewmember	Average Weight	Average Weight with Bags
Flight crewmember	190 lb	240 lb
Flight attendant	170 lb	210 lb
Male flight attendant	180 lb	220 lb
Female flight attendant	160 lb	200 lb
Crewmember roller bag	30 lb	NA
Pilot flight bag	20 lb	NA
Flight attendant kit	10 lb	NA

b. The flight crewmember weights provided in Table 2-3 were derived from weights listed on all first- and second-class medical certificates. The flight crewmember weight with bags assumes that each flight crewmember has one crewmember roller bag and one pilot flight bag.

c. The flight attendant weights provided in Table 2-3 were derived from the NHANES data. (For additional information on NHANES, see Appendix 2.) The flight attendant weights with bags assume that each flight attendant has one crewmember roller bag and one flight attendant kit.

d. An operator may include the weight of crewmembers in an aircraft's OEW or add the weight to the load manifest prepared for each flight.

207. What weights may be used for company materials, freight, and mail?

a. Company Materials and Freight. An operator should use actual weights for company materials, aircraft parts, and freight carried aboard an aircraft.

b. Mail. An operator should use the weights provided with manifested mail shipments to account for the weight of the mail. If an operator has to separate a shipment of mail, the operator may make actual estimates about the weight of the individual pieces, provided the sum of the estimated weights is equal to the actual manifested weight of the entire shipment.

208. What are the standard average weights for special passenger groups that do not fit an operator's standard average weight profile?

a. Actual passenger weights should be used for nonstandard weight groups (sports teams, etc.) unless average weights have been established for such groups by conducting a survey in accordance with the procedures established in Section 3 of this chapter. When such groups form only a part of the total passenger load, actual weights, or established average weights for the nonstandard group, may be used for such exception groups and average weights used for the balance of the passenger load. In such instances, a notation should be made in the load manifest indicating the number of persons in the special group and identifying the group; e.g., football squad, etc.

b. Roster weights may be used for determining the actual passenger weight.

c. A standard allowance of 16 pounds per person may be used to account for carry-on and personal items as provided in the operator's approved carry-on bag program.

d. If the carry-on bags are representative of the operator's profile but do not meet the number of bags authorized per person, the operator may count bags and use a 16-pound per bag allocation.

e. Actual weights must be used in cases where the carry-on bags are not representative of the operator's profile.

f. Groups that are predominantly male or female should use the standard average weights for males or females provided in Table 2-1.

g. For military groups, the Department of Defense (DOD) requires actual passenger and cargo weights be used in computing the aircraft weight and balance for all DOD charter missions. This requirement is specified in DOD Commercial Air Carrier Quality and Safety requirements (reference Title 32 of the Code of Federal Regulations part 861, section 861.4(e)(3)(ix), current edition). FAA-approved air carrier weight and balance control programs may be used to account for carry-on/personal items for mixed loads of military and their dependents (such as channel missions). For combat-equipped troop charters, the Air Mobility Command (AMC) will provide guidance to account for the additional weight. If aircraft operators perceive that the weights provided are understated, they should seek confirmation of the actual weights and should make reasonable upward estimations and adjustments to those passenger and/or bag weights.

Section 3. Average Weights Based on Survey Results

209. What should an operator consider when designing a survey?

a. This section provides operators with an acceptable survey method to use in determining average weights for a weight and balance control program. This section also describes how an operator can conduct a survey to count personal items and carry-on bags to determine an appropriate allowance for those items to include in passenger weight. In addition, an operator may use the methods described in this section to conduct a survey to determine the percentage of male and female passengers, to calculate an average passenger weight.

b. Surveys conducted correctly allow an operator to draw reliable inferences about large populations based on relatively small sample sizes. In designing a survey, an operator should consider—

(1) The sample size required to achieve the desired reliability,

(2) The sample selection process, and

(3) The type of survey (average weights or a count of items).

210. What sample sizes should an operator use?

Several factors must be considered when determining an adequate sample size. The more varied the population, the larger the sample size required to obtain a reliable estimate. Paragraph 211 provides a formula to derive the absolute minimum sample size to achieve a 95-percent confidence level. Table 2-4 has been provided for those operators that wish to use calculations other than those listed in paragraph 211. Table 2-4 provides the operator with an acceptable number of samples that may be collected to obtain a 95-percent confidence level and lists the tolerable error associated with each category.

TABLE 2-4. MINIMUM SAMPLE SIZES

Survey Subject	Minimum Sample Size	Tolerable Error
Adult (standard adult/male/female)	2,700	1%
Child	2,700	2%
Checked bags	1,400	2%
Heavy bag	1,400	2%
Plane-side loaded bags	1,400	2%
Personal items and carry-on bags	1,400	2%
Personal items only (for operators with a no carry-on bag program)	1,400	2%

211. When conducting a survey, can an operator collect a smaller sample size than that published in Table 2-4?

If the operator has chosen to use a sample size that is smaller than that provided in Table 2-4, the operator should collect a sufficient number of samples to satisfy the following formulas:

$$s = \frac{\sqrt{\sum_{j=1}^{n}(x_j - \bar{x})^2}}{\sqrt{n-1}}$$

Where:

s is the standard deviation

n is the number of points surveyed

x_j is the individual survey weights

$\bar{x}$ is the sample average

$$e = \frac{1.96 * s * 100}{\sqrt{n} * \bar{x}}$$

Where:

e is the tolerable error percentage

212. What sampling method should an operator use?

a. An operator conducting a survey must employ random sampling techniques. Random sampling means that every member of a group has an equal chance of being selected for inclusion in the sample. If an operator conducts a survey that does not employ random sampling, the characteristics of the selected sample may not be indicative of the larger group as a whole. Because of this, any conclusions drawn from such a survey may not be valid.

b. The following are two examples of random sampling methods that an operator may find appropriate for the type of survey conducted. An operator may also consult a basic textbook on statistics to determine if another random sampling method is more appropriate.

(1) Simple random selection. An operator should assign a sequential number to each item in a group (such as passengers waiting on a line or bag claim tickets). Then the operator randomly selects numbers and includes the item corresponding with the number in the sample. The operator repeats this process until it has obtained the minimum sample size.

(2) Systematic random selection. An operator should randomly select an item in sequence to begin the process of obtaining samples. The operator should then use a predetermined, systematic process to select the remaining samples following the first sample. For example, an operator selects the third person in line to participate in the survey. The operator then selects every fifth person after that to participate in the survey. The operator continues selecting items to include in the sample until it has obtained the minimum sample size.

c. Regardless of the sampling method used, an operator has the option of surveying each passenger and bag aboard the aircraft and should always give a passenger the right to decline to participate in any passenger or bag weight survey. If a passenger declines to participate, the operator should select the next passenger based on the operator's random selection method rather than select the next passenger in a line. If a passenger declines to participate, an operator should not attempt to estimate data for inclusion in the survey.

213. What should an operator consider when developing a survey plan and submitting it to the FAA?

a. Developing a Survey Plan. Before conducting a survey, an operator should develop a survey plan. The plan should describe the dates, times, and locations the survey will take place. In developing a survey plan, the operator should consider its type of operation, hours of operation, markets served, and frequency of flights on particular routes. An operator should avoid conducting surveys on holidays unless it has a valid reason to request the particular date.

b. Submitting the Survey Plan to the FAA. It is recommended that an operator submit its survey plan to the FAA at least 2 weeks before the survey is expected to begin. Before the survey begins, the operator's principal inspectors (PI) will review the plan and work with the operator to develop a mutually acceptable plan. During the survey, the PI will oversee the survey process to validate the execution of the survey plan. After the survey is complete, the PI will review the survey results and issue the appropriate OpSpecs or MSpecs. Once a survey begins, the operator should continue the survey until complete, even if the initial survey data indicates that the average weights are lighter or heavier than expected.

214. What general survey procedures should an operator use?

a. Survey Locations. An operator should accomplish a survey at one or more airports that represent at least 15 percent of an operator's daily departures. To provide connecting passengers with an equal chance of being selected in the survey, an operator should conduct its survey within the secure area of the airport. An operator should select locations to conduct its survey that would provide a sample that is random and representative of its operations. For example, an operator should not conduct a survey at a gate used by shuttle operations unless the operator is conducting a survey specific to that route or the operator only conducts shuttle operations.

b. Weighing Passengers. An operator that chooses to weigh passengers as part of a survey should take care to protect the privacy of passengers. The scale readout should remain hidden from public view. An operator should ensure that any passenger weight data collected remains confidential.

c. Weighing Bags. When weighing bags on a particular flight, an operator should take care to ensure that it is properly accounting for all items taken aboard the aircraft.

d. Rounding Sample Results. If the operator uses rounding in the weight and balance calculations, it is recommended that the operator round passenger weights to the nearest pound and bag weights to the nearest half-pound. An operator should ensure that rounding is done consistently in all calculations.

NOTE: If an operator elects to use average child weights, they should be used on a flight-by-flight basis and not factored into the average passenger weight (whether using standard average or segmented weights).

e. Surveys for Particular Routes. An operator may conduct a survey for a particular route if the operator believes that the average weights on that route may differ from those in the rest of its operations. To establish a standard average passenger weight along the route, an operator may survey passengers at only one location. However, an operator should conduct surveys of personal items and bags at the departure and arrival locations, unless the operator can verify there is no significant difference in the weight and number of bags in either direction along the route.

215. What information might an operator gain from conducting a count survey?

a. An operator may conduct a survey to count certain items without determining the weight of those items. For example, an operator may determine that the standard average weights for male and female passengers are appropriate for its operations, but on some routes the passengers are predominantly male or female. In this case, an operator may conduct a survey to determine the percentage of male and female passengers. The operator could use the results of the survey to justify a weight other than the standard weights, which assume a 50-percent male and 50-percent female mix of passengers. Similarly, an operator may conduct a survey to determine the number of personal items and carry-on bags passengers carry aboard aircraft to determine if the allowance of 16 pounds per passenger is appropriate to its operations.

b. For example, an operator conducts a survey on a particular route (or multiple routes if amending the program average weight) to count the percentage of passengers carrying personal items and carry-on bags. The operator finds that—

(1) Fifty percent of passengers carry one carry-on bag and one personal item.

(2) Thirty percent of passengers carry one carry-on bag or one personal item.

(3) Twenty percent of passengers carry neither a carry-on bag nor a personal item.

(4) The survey results show that the average passenger carries approximately 21 pounds of personal items and carry-on bags rather than the standard allowance of 16 pounds. In such a case, it would be irresponsible for the operator to fail to increase the standard average weights for that route(s) by 5 pounds per passenger.

NOTE: The calculation below determines the appropriate allowance for personal items and carry-on bags.

$$[0.50 \times (16 \text{ pounds} + 16 \text{ pounds})] + [0.30 \times (16 \text{ pounds})] + [0.20 \times (0 \text{ pounds})] = 20.8 \text{ pounds}$$

216. When should an operator conduct another survey to revalidate the data from an earlier survey?

In order to use survey-derived average weights, an operator must revalidate such survey data every 36 calendar-months or revert to the standard average weights, provided the new survey average weight results are within 2 percent of the standard average weights listed in this AC.

Section 4. Segmented Passenger Weights

217. What should an operator consider when using segmented weights?

a. The concept of segmented weights involves adding a portion of the standard deviation to an average weight to increase the confidence that the actual weight will not exceed the average weight. Like the standard average weights in Section 2, the segmented weights in Table 2-5 were derived from average weights and standard deviations found based on NHANES data, assuming a 95-percent confidence interval and 1-percent tolerable error.

TABLE 2-5. SEGMENTED WEIGHTS FOR ADULT PASSENGERS (IN POUNDS; SUMMER)

Maximum Certificated Passenger Seating Capacity	Ratio of Male to Female Passengers										
	0/100	10/90	20/80	30/70	40/60	50/50	60/40	70/30	80/20	90/10	100/0
1 to 4	Use actual weights, or asked (volunteered) weights plus 10 lb										
5	231	233	235	237	239	241	243	245	247	249	251
6 to 8	219	221	223	225	227	229	231	233	235	237	239
9 to 11	209	211	213	215	217	219	221	223	225	227	229
12 to 16	203	205	207	209	211	213	215	217	219	221	223
17 to 25	198	200	202	204	206	208	210	212	214	216	218
26 to 30	194	196	198	200	202	204	206	208	210	212	214
31 to 53	191	193	195	197	199	201	203	205	207	209	211
54 to 70 +	188	190	192	194	196	198	200	202	204	206	208

b. An operator may make the following adjustments to the table above:

(1) An operator may subtract 6 pounds from the passenger weight outlined above if it has a no-carry-on bag program or does not allow any carry-on baggage into the cabin of the aircraft.

(2) An operator should add 5 pounds to the weights above during the winter season.

c. An operator may interpolate between columns on the chart if the operator's assumed ratio of male passengers to female passengers does not exactly match the values given.

d. To account for a child's weight, for children ages 2 years to less than 13 years of age, the standard average child weight located in Table 2-1 may be used. Weights of children under the age of 2 have been factored into the segmented adult passenger weight.

218. How are loading envelope curtailment and bag weight affected by an operator's use of segmented weights?

a. Loading Envelope Curtailment. An operator using segmented passenger weights may use the standard average passenger weights when curtailing its operational loading envelope using the methods described in Appendixes 3 and 4.

b. Bag Weights. An operator using segmented weights may use actual weights for bags or the standard average bag weights provided in Section 2. An operator using segmented passenger weights *may not* use survey-derived average bag weights.

219. What might be an example be of an operator using the segmented weights in Table 2-5?

An operator of a 30 passenger-seat aircraft conducts a survey to count the percentage of male and female passengers on its flights and determines that 50 percent of the passengers are male and 50 percent are female. If the operator has an approved carry-on bag program, the operator should use 204 pounds in the summer and 209 pounds in the winter. If the operator has a no-carry-on bag program, the operator should use 198 pounds in the summer and 203 pounds in the winter and account for all plane-side loaded bags as 20 pounds each.

Section 5. Actual Weight Programs

220. If the operator decides to use an actual weight program, how might it determine the actual weight of passengers?

An operator may determine the actual weight of passengers by—

a. Weighing each passenger on a scale before boarding the aircraft (types of weight scales and scale tolerances will be defined in the operator's approved weight and balance control program); or

b. Asking each passenger his or her weight. An operator should add to this asked (volunteered) weight at least 10 pounds to account for clothing. An operator may increase this allowance for clothing on certain routes or during certain seasons, if appropriate.

NOTE: If an operator believes that the weight volunteered by a passenger is understated, the operator should make a reasonable estimate of the passenger's actual weight and add 10 pounds.

221. If the operator decides to use an actual weight program, how should it determine the actual weights of personal items and bags?

To determine the actual weight of a personal item, carry-on bag, checked bag, plane-side loaded bag, or a heavy bag, an operator should weigh the item on a scale.

222. What approach should an operator use to record actual weights?

An operator using actual weights should record all weights used in the load buildup.

CHAPTER 3. OPERATOR REPORTING SYSTEMS AND FAA OVERSIGHT

Section 1. Pilot and Agent Reporting Systems

300. What are the pilots' and operators' responsibilities in reporting aircraft loading and manifest preparation discrepancies?

Each operator should develop a reporting system and encourage employees to report any discrepancies in aircraft loading or manifest preparation. These discrepancies may include errors in documentation or calculation, or issues with aircraft performance and handling qualities that indicate the aircraft weight or balance is not accurate. Operators should attempt to determine the cause of each discrepancy and take appropriate corrective action. This would include a load audit on affected flights or conducting a passenger or bag weight survey in accordance with this AC if trends indicate it is warranted.

Section 2. FAA Oversight

301. Which FAA inspectors are responsible for overseeing an operator's weight and balance program?

The FAA has divided the responsibility of overseeing an operator's weight and balance control program between the operator's principal operations inspector (POI) and principal maintenance inspector (PMI). An operator that wishes to change aspects of its weight and balance control program, including average weights, should submit all applicable supporting data to the POI and PMI, as applicable, for approval. If the FAA approves the changes, the FAA will issue revised OpSpecs, MSpecs, or LOA, as appropriate.

302. Which portions of OpSpecs or MSpecs are relevant to an operator's weight and balance program?

a. This AC details methods to develop a weight and balance control program with greater accuracy and increased flexibility. By changing its OpSpecs or MSpecs, an operator may alter the weights used in its weight and balance control program to include appropriate combinations of standard average weights, average weights based on survey results, or actual weights.

b. Parts A and E of OpSpecs or MSpecs authorize an operator's weight and balance control program. These parts will address—

(1) Average passenger and bag weights;

(2) Situations when the use of average weights is inappropriate;

(3) The treatment of charter flights or special groups, if applicable;

(4) The type of loading schedule and instructions for its use;

(5) Aircraft weighing schedules; and

(6) Other procedures that the operator may require to assure control of weight and balance.

c. OpSpec or MSpec paragraph E096, Weight and Balance Control Procedures, is issued to an operator with an approved aircraft weight program. The FAA issues this paragraph after reviewing and approving the operator's aircraft weight and balance control procedures in their entirety.

d. OpSpec or MSpec paragraph A011, Approved Carry-on Baggage Program, is issued to an operator with an approved carry-on bag program. This paragraph provides details about the operator's approved carry-on bag program and states whether the operator has a carry-on bag program or a no-carry-on bag program. The FAA will issue this paragraph after reviewing the operator's carry-on baggage program in its entirety.

e. If an operator chooses to use standard average weights as outlined in this AC, the FAA will document that decision by issuing one or more of the following OpSpecs or MSpecs paragraphs. If an operator proposes to use different average weights (weights other than the standard average or segmented weights) and the FAA concurs with the statistically valid data provided by the operator to support such average weight differences, then those differences will be documented in the following OpSpecs or MSpecs. Although these paragraphs authorize an operator to use average and/or segmented weights, an operator may use actual weights at any time once issued these paragraphs.

(1) Paragraph A097—Small Cabin Aircraft Passenger and Baggage Weight Program.

(2) Paragraph A098—Medium Cabin Aircraft Passenger and Baggage Weight Program.

(3) Paragraph A099—Large Cabin Aircraft Passenger and Baggage Weight Program.

NOTE: If an operator does not provide the FAA with adequate information to justify the issuance of one of the above paragraphs that documents the use of standard average, survey-derived average, and/or segmented weights, the FAA may issue paragraph A096, Actual Passenger and Baggage Weight Program for All Aircraft, requiring the operator to use actual passenger and bag weights. Any operators using only an actual weight program must be issued paragraphs A096 and E096.

f. If an operator chooses to develop a weight and balance control program using only actual weights for all the aircraft it operates, the FAA may issue OpSpec/MSpec paragraph A096. The FAA will not issue paragraphs A097, A098, or A099 to operators with a weight and balance control program that uses only actual weights. The FAA will only issue paragraphs A096, A097, A098, and/or A099 after reviewing the operator's actual or average weight program.

g. An operator that receives approval to use survey-derived (nonstandard) average weights should document and make available, upon request, the data and methodology used to derive those weights. An operator's documentation should be sufficiently comprehensive to allow the FAA to reproduce the same results during an audit. An operator should retain this documentation for as long as the operator uses the survey-derived average weights in its weight and balance control program.

h. If an operator chooses to conduct a survey, the operator will use the results of the survey to establish a revised average weight and must curtail the loading envelope as necessary. However, if the survey results indicate the average weights are within 2 percent of the standard average weights outlined in this AC, the operator may elect to adopt the standard average weights only after submitting the survey results to the FAA and receiving approval through its OpSpecs, MSpecs, or LOA.

i. For operators using an onboard weight and balance system to determine the weight and balance of the aircraft, the FAA will issue OpSpecs or MSpecs paragraph A096. Paragraph A096 documents the use of actual weights and the use of its onboard weight and balance system. For an operator that chooses to use standard average weights as a backup system, the FAA will issue paragraphs A097, A098, or A099, as appropriate. By authorizing the use of average weights, the operator may elect to use actual weights derived from its onboard weight and balance system, and may use average weights as an alternative should the system be inoperative.

j. For operators of all-cargo aircraft, the FAA will issue OpSpecs paragraph A096. Paragraph A096 documents the use of actual weights, with the exception of flightcrew, supernumeraries, and their bag weights. These weights may be accounted for using the standard average weights described in Chapter 2, Table 2-3.

APPENDIX 1. DEFINITIONS

1. Basic empty weight. The aircraft empty weight, adjusted for variations in standard items.

2. Cargo. As used in this advisory circular (AC), cargo refers to everything carried in the cargo compartments of the aircraft. This includes bags, mail, freight, express, and company material. It also includes live animals, dangerous goods, and hazardous materials as subcategories of the above.

3. Carry-on bag. A bag that the operator allows the passenger to carry onboard. It should be of a size and shape that will allow it to be stowed under the passenger seat or in a storage compartment. The operator establishes the exact dimensional limits based on the particular aircraft stowage limits.

4. Certificated weight and CG limits. Weight and center of gravity (CG) limits are established at the time of aircraft certification. They are specified in the applicable aircraft flight manual (AFM).

5. Checked bags. Checked bags are those bags placed in the cargo compartment of the aircraft. This includes bags that are too large to be placed in the cabin of the aircraft or those bags that are required to be carried in the cargo compartment by regulation, security program, or company policy. For bags checked plane-side, see the definition for plane-side loaded bags.

6. Curtailment. Creating an operational loading envelope that is more restrictive than the manufacturers' CG envelope, to assure the aircraft will be operated within limits during all phases of flight. Curtailment typically accounts for, but is not limited to, in-flight movement, gear and flap movement, cargo variation, fuel density, fuel burn-off, and seating variation.

7. Fleet operational empty weight (FOEW). Average operational empty weight (OEW) used for a fleet or group of aircraft of the same model and configuration.

8. Freight. Cargo carried for hire in the cargo compartment that is not mail or passenger bags.

9. Heavy bags. Heavy bags are considered any bag that weighs more than 50 pounds but less than 100 pounds. Bags that are 100 pounds or more are considered freight.

10. Large cabin aircraft. Aircraft originally type-certificated with a maximum seating capacity of 71 or more passenger seats.

11. Loading envelope. Weight and CG envelope used in a loading schedule. Loading the aircraft within the loading envelope will maintain the aircraft weight and CG within the manufacturer's type-certificated limits throughout the flight.

12. Loading schedule. Method for calculating and documenting aircraft weight and balance prior to taxiing, to ensure the aircraft will remain within all required weight and balance limitations throughout the flight.

13. Maximum landing weight. The maximum weight at which the aircraft may normally be landed.

14. Maximum takeoff weight. The maximum allowable aircraft weight at the start of the takeoff run.

15. Maximum taxi weight. The maximum allowable aircraft weight for taxiing.

16. Maximum zero-fuel weight. The maximum permissible weight of an aircraft with no disposable fuel and oil.

17. Mean Aerodynamic Chord (MAC). The MAC is established by the manufacturer, which defines its leading edge and its trailing edge in terms of distance (usually inches) from the datum. The CG location and various limits are then expressed in percentages of the chord. The location and dimensions of the MAC can be found in the aircraft specifications, the type certificate data sheet, the AFM, or the aircraft weight and balance manual.

18. Medium cabin aircraft. Aircraft originally type-certificated with a maximum seating capacity between 70 and 30 passenger seats, inclusive.

19. Moment. The moment is the product of a weight multiplied by its arm. The moment of an item about the datum is obtained by multiplying the weight of the item by its horizontal distance from the datum.

20. Onboard weight and balance system. A system that weighs an aircraft and payload, then computes the CG using equipment onboard the aircraft.

21. Operational empty weight (OEW). Basic empty weight or fleet empty weight plus operational items.

22. Operational items. Personnel, equipment, and supplies necessary for a particular operation but not included in basic empty weight. These items may vary for a particular aircraft and may include, but are not limited to, the following:

a. Crewmembers, supernumeraries, and bags;

b. Manuals and navigation equipment;

c. Passenger service equipment, including pillows, blankets, and magazines;

d. Removable service equipment for cabin, galley, and bar;

e. Food and beverage, including liquor;

f. Usable fluids, other than those in useful load;

g. Required emergency equipment for all flights;

h. Life rafts, life vests, and emergency transmitters;

i. Aircraft unit load devices;

j. Potable water;

k. Drainable unusable fuel;

l. Spare parts normally carried aboard and not accounted for as cargo; and

m. All other equipment considered standard by the operator.

23. Passenger assist/comfort animals and devices. These include, but are not limited to, canes, crutches, walkers, wheelchairs, medically-required animal comfort companions, or animals required to assist the vision impaired.

24. Passenger weight. Passenger weight is the actual weight or the approved average weight of the passenger.

a. An adult is defined as an individual 13 years or older.

b. A child is defined as an individual aged 2 to less than 13 years of age.

c. Infants are children who have not yet reached their second birthday and are considered part of the adult standard average and segmented passenger weight.

25. Personal item. Items the operator may allow a passenger to carry aboard, in addition to a carry-on bag. Typically, an operator may allow one personal item such as a purse, briefcase, computer and case, camera and case, diaper bag, or an item of similar size. Other items, such as coats, umbrellas, reading material, food for immediate consumption, infant restraining device, and passenger assist/comfort animals and devices, are allowed to be carried on the aircraft and are not counted against the personal item allowance.

26. Plane-side loaded bag. Any bag or item that is placed at the door or steps of an aircraft and subsequently placed in the aircraft cargo compartment or cargo bin.

27. Reference Balance Arm (BA). The horizontal distance from the reference datum to the CG of an item.

28. Segmented weights. Passenger weights derived by adding a portion of the standard deviation to an average weight to increase the confidence that the actual weight will not exceed the average weight.

29. Small cabin aircraft. Aircraft originally type certificated with a maximum seating capacity between 5 and 29 passenger seats, inclusive.

30. Standard deviation. One of several indexes of variability that statisticians use to characterize the dispersion among the measures in a given population.

31. Standard items. Equipment and fluids not considered an integral part of a particular aircraft and not a variation for the same type of aircraft. These items may include, but are not limited to, the following:

a. Unusable fuel and other unusable fluids;

b. Engine oil;

c. Toilet fluid and chemical;

d. Fire extinguishers, pyrotechnics, and emergency oxygen equipment;

e. Structure in galley, buffet, and bar; and

f. Supplementary electronic equipment.

32. Useful Load. Difference between takeoff weight and OEW. It includes payload, usable fuel, and other usable fluids not included as operational items.

APPENDIX 2. SOURCE OF STANDARD AVERAGE WEIGHTS

1. Standard Average Passenger Weights.

a. The Federal Aviation Administration (FAA) examined data from several large-scale, national health studies conducted by U.S. Government health agencies. The FAA found that the National Health and Nutrition Examination Survey (NHANES), conducted by the Centers for Disease Control (CDC), provided the most comprehensive and appropriate data. The data in NHANES cover a broad spectrum of the general population, are based on a large sample size, and are not restricted geographically to a particular area.

b. The CDC collects NHANES data annually by conducting an actual scale weighing of approximately 9,000 subjects in a clinical setting. The standard deviation of the sample was 47 pounds. The CDC last published results from NHANES in 2000. Additional information on NHANES and the data points used to derive average weights in this advisory circular are at:

(1) General information.
http://www.cdc.gov/nchs/nhanes.htm

(2) Analytic and reporting guidelines.
http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf

(3) Data files for 1999–2000 survey.
http://www.cdc.gov/nchs/about/major/nhanes/NHANES99_00.htm

c. The FAA used the most recent NHANES data set available from surveys conducted in 1999 and 2000 to calculate the standard average passenger weights used in this advisory circular (AC). From this data set, the FAA separated out a separate data set of individuals who had not yet reached their 13th birthday to determine average child weight. From the remaining adult data set, the FAA removed all weight data that indicated the subject was clothed during the weighing and removed all data points more than two standard deviations from the mean. The FAA then calculated the average weights for males and females in the remaining data set.

2. Standard Average Bag Weights.

To determine standard average weights for different types of bags, the FAA closely examined previous surveys conducted by operators, including several surveys conducted in response to FAA Notice 8400.40, Weight and Balance Control Programs for 10 to 19 Seat Airplanes Operated Under 14 CFR 121. The results of those surveys are summarized in Table 2-1.

TABLE 2-1. BAG SURVEY RESULTS

Item Surveyed	Average Weight	Standard Deviation
Personal items and carry-on bags	15.1 lb	8.2 lb
Checked bags	28.9 lb	10.8 lb
Heavy bags	58.7 lb	7.2 lb

APPENDIX 3. SAMPLE OPERATIONAL LOADING ENVELOPE

1. Introduction.

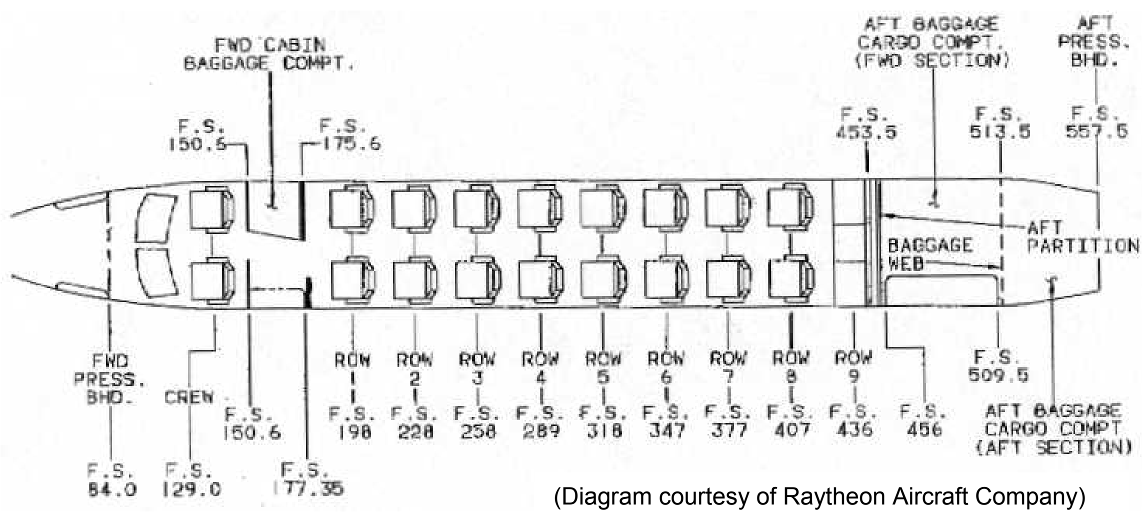
The following is an example of how to develop an operational loading envelope. For this example, a hypothetical 19-seat commuter category aircraft is used. Although this example uses inches to measure fuselage station, an operator may choose to use an index system for convenience.

2. Assumptions for This Example.

a. Passenger weight. Because the aircraft is certificated under the commuter category of Title 14 of the Code of Federal Regulations (14 CFR) part 23 and because it is originally type-certificated for 5 or more passenger seats, it would be appropriate to use the average weights listed in Chapter 2, Section 2. For this example, it is assumed that the operator has a no-carry-on baggage program. Therefore, the operator should use a standard average passenger weight of 189 pounds in winter and 184 pounds in summer. For this example, a standard average passenger weight of 189 pounds is used. The operator also assumes that passengers are distributed throughout the cabin in accordance with the window-aisle-remaining method. Note that because this aircraft has only two window seats per row, the operator may reasonably assume that passengers begin seating themselves in the front of the cabin and select the most forward seat available.

b. Bag weights. For this example, the operator assumes that a checked bag weighs 30 pounds and a plane-side loaded bag weighs 20 pounds.

c. Interior seating. For this example, consider a commuter category 19-seat aircraft with the interior seating diagram shown in Figure 3-1. For this example, the fusleage station (F.S.) of each seat row is the seated passenger centroid. (For other diagrams this may not be true.)



(Diagram courtesy of Raytheon Aircraft Company)

FIGURE 3-1. SAMPLE AIRCRAFT INTERIOR SEATING DIAGRAM

3. Curtailments for Passenger Seating Variation.

a. Establishing zones. The operator elects to separate the passenger cabin into three zones. Zone 1 will contain rows 1 to 3, zone 2 will contain rows 4 to 6, and zone 3 will contain rows 7 to 9.

b. Determining the centroid of each zone. When using cabin zones, an operator assumes that all passengers are sitting at the centroid of their zone. To find the centroid of each zone—

(1) Multiply the number of seats in each row of the zone by the location of the row,

(2) Add each number calculated in step 1, and

(3) Divide the number in step 2 by the total number of seats in the zone.

NOTE: For this sample aircraft, see Tables 3-1 through 3-3 below.

TABLE 3-1. CALCULATION OF ZONE 1 CENTROID

Row No.	No. of Seats	Row Location	No. of Seats × Row Location
1	2	198 in	396 in
2	2	228 in	456 in
3	2	258 in	516 in
TOTAL	6	NA	1,368 in
1,368 in / 6 seats = 228 in			

TABLE 3-2. CALCULATION OF ZONE 2 CENTROID

Row No.	No. of Seats	Row Location	No. of Seats × Row Location
4	2	289 in	578 in
5	2	318 in	636 in
6	2	347 in	694 in
TOTAL	6	NA	1,908 in
1,908 in / 6 seats = 318 in			

TABLE 3-3. CALCULATION OF ZONE 3 CENTROID

Row No.	No. of Seats	Row Location	No. of Seats × Row Location
7	2	377 in	754 in
8	2	407 in	814 in
9	3	436 in	1,308 in
TOTAL	7	NA	2,876 in
2,876 in / 7 seats = 411 in			

c. Comparing loading assumptions. To determine the appropriate amount of curtailment, the operator should compare aircraft loading based on the window-aisle-remaining assumption with aircraft loaded based on the assumption that passengers are sitting at the centroid of their respective zones. An operator may determine the appropriate curtailment by comparing the moments resulting from these assumptions and identifying the loading scenarios that result in the most forward or aft center of gravity (CG) location. See Tables 3-4 through 3-12 below.

(1) Curtailment calculation for zone 1.

TABLE 3-4. MOMENTS RESULTING FROM THE ZONE CENTROID ASSUMPTION FOR ZONE 1

Passenger No.	Assumed Weight	Assumed Arm	Moment	Cumulative Moment
1	189 lb	228 in	43,092 in-lb	43,092 in-lb
2	189 lb	228 in	43,092 in-lb	86,184 in-lb
3	189 lb	228 in	43,092 in-lb	129,276 in-lb
4	189 lb	228 in	43,092 in-lb	172,368 in-lb
5	189 lb	228 in	43,092 in-lb	215,460 in-lb
6	189 lb	228 in	43,092 in-lb	258,552 in-lb

TABLE 3-5. MOMENTS RESULTING FROM THE WINDOW-AISLE-REMAINING ASSUMPTION FOR ZONE 1

Passenger No.	Assumed Row	Weight	Arm	Moment	Cumulative Moment
1	1	189 lb	198 in	37,422 in-lb	37,422 in-lb
2	1	189 lb	198 in	37,422 in-lb	74,844 in-lb
3	2	189 lb	228 in	43,092 in-lb	117,936 in-lb
4	2	189 lb	228 in	43,092 in-lb	161,028 in-lb
5	3	189 lb	258 in	48,762 in-lb	209,790 in-lb
6	3	189 lb	258 in	48,762 in-lb	258,552 in-lb

TABLE 3-6. COMPARISON OF MOMENTS FOR ZONE 1

Passenger No.	Cumulative Moment from the Zone Centroid Assumption	Cumulative Moment from the Window-Aisle-Remaining Assumption	Difference
1	43,092 in-lb	37,422 in-lb	-5,670 in-lb
2	86,184 in-lb	74,844 in-lb	-11,340 in-lb
3	129,276 in-lb	117,936 in-lb	-11,340 in-lb
4	172,368 in-lb	161,028 in-lb	-11,340 in-lb
5	215,460 in-lb	209,790 in-lb	-5,670 in-lb
6	258,552 in-lb	258,552 in-lb	0 in-lb

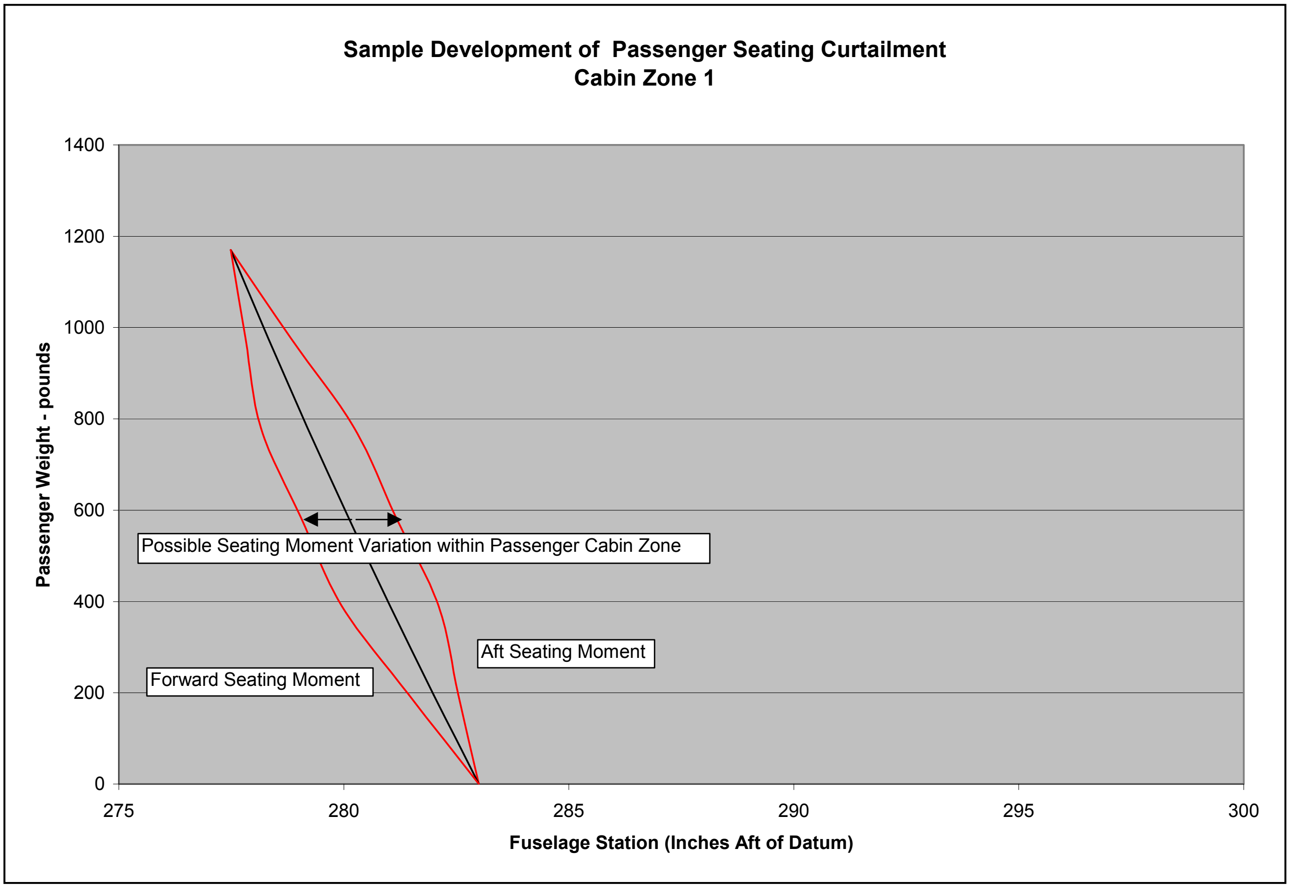


FIGURE 3-2. SAMPLE PASSENGER SEATING MOMENT (ZONE 1)

(2) Curtailment calculation for zone 2.

TABLE 3-7. MOMENTS RESULTING FROM THE ZONE CENTROID ASSUMPTION FOR ZONE 2

Passenger No.	Assumed Weight	Assumed Arm	Moment	Cumulative Moment
7	189 lb	318 in	60,102 in-lb	60,102 in-lb
8	189 lb	318 in	60,102 in-lb	120,204 in-lb
9	189 lb	318 in	60,102 in-lb	180,306 in-lb
10	189 lb	318 in	60,102 in-lb	240,408 in-lb
11	189 lb	318 in	60,102 in-lb	300,510 in-lb
12	189 lb	318 in	60,102 in-lb	360,612 in-lb

TABLE 3-8. MOMENTS RESULTING FROM THE WINDOW-AISLE-REMAINING ASSUMPTION FOR ZONE 2

Passenger No.	Assumed Row	Weight	Arm	Moment	Cumulative Moment
7	4	189 lb	289 in	54,621 in-lb	54,621 in-lb
8	4	189 lb	289 in	54,621 in-lb	109,242 in-lb
9	5	189 lb	318 in	60,102 in-lb	169,344 in-lb
10	5	189 lb	318 in	60,102 in-lb	229,446 in-lb
11	6	189 lb	347 in	65,583 in-lb	295,029 in-lb
12	6	189 lb	347 in	65,583 in-lb	360,612 in-lb

TABLE 3-9. COMPARISON OF MOMENTS FOR ZONE 2

Passenger No.	Cumulative Moment from the Zone Centroid Assumption	Cumulative Moment from the Window-Aisle-Remaining Assumption	Difference
7	60,102 in-lb	54,621 in-lb	-5,481 in-lb
8	120,204 in-lb	109,242 in-lb	-10,962 in-lb
9	180,306 in-lb	169,344 in-lb	-10,962 in-lb
10	240,408 in-lb	229,446 in-lb	-10,962 in-lb
11	300,510 in-lb	295,029 in-lb	-5,481 in-lb
12	360,612 in-lb	360,612 in-lb	0 in-lb

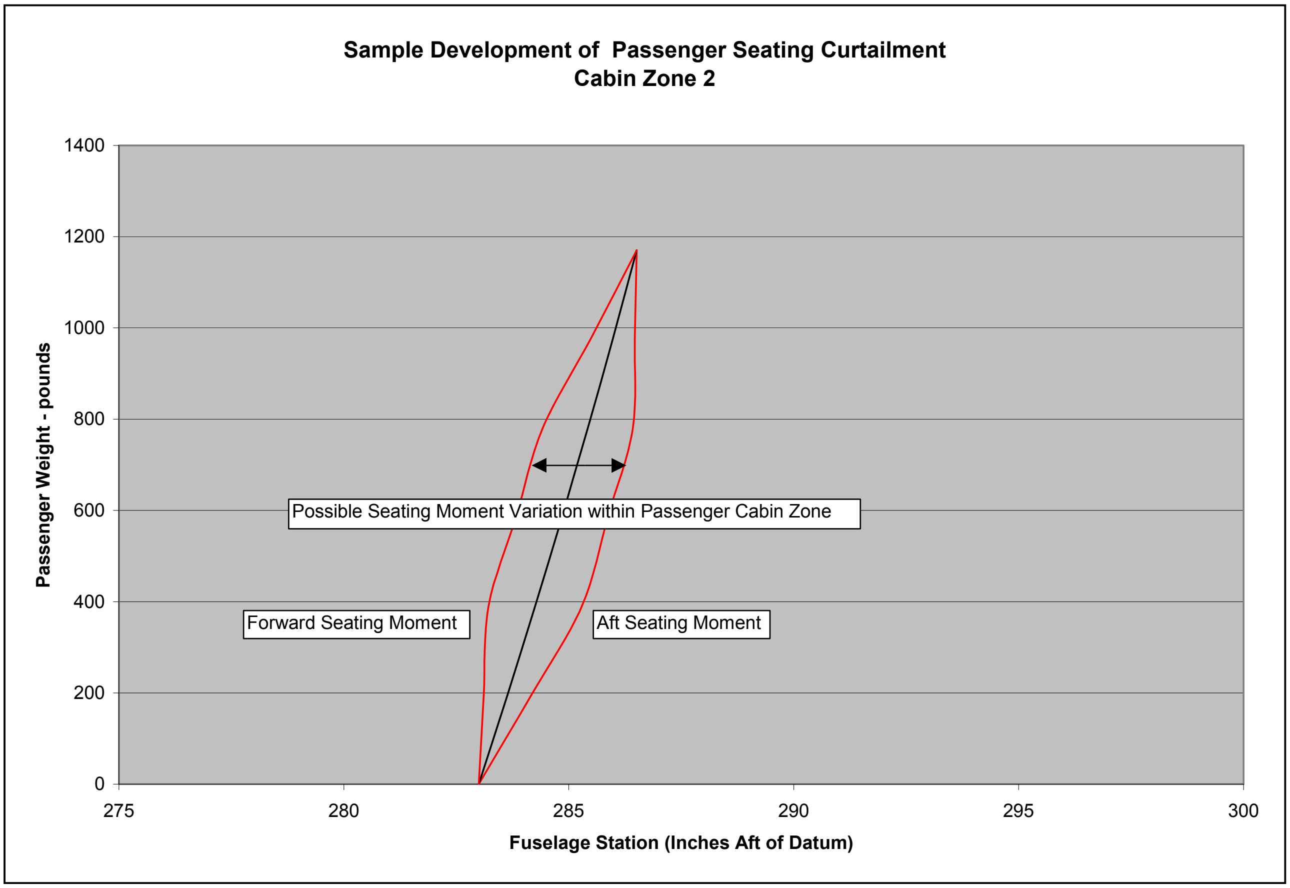


FIGURE 3-3. SAMPLE PASSENGER SEATING MOMENT (ZONE 2)

(3) Curtailment calculation for zone 3.

TABLE 3-10. MOMENTS RESULTING FROM THE ZONE CENTROID ASSUMPTION FOR ZONE 3

Passenger No.	Assumed Weight	Assumed Arm	Moment	Cumulative Moment
13	189 lb	411 in	77,679 in-lb	77,679 in-lb
14	189 lb	411 in	77,679 in-lb	155,358 in-lb
15	189 lb	411 in	77,679 in-lb	233,037 in-lb
16	189 lb	411 in	77,679 in-lb	310,716 in-lb
17	189 lb	411 in	77,679 in-lb	388,395 in-lb
18	189 lb	411 in	77,679 in-lb	466,074 in-lb
19	189 lb	411 in	77,679 in-lb	543,753 in-lb

TABLE 3-11. MOMENTS RESULTING FROM THE WINDOW-AISLE-REMAINING ASSUMPTION FOR ZONE 3

Passenger No.	Assumed Row	Weight	Arm	Moment	Cumulative Moment
13	7	189 lb	377 in	71,253 in-lb	71,253 in-lb
14	7	189 lb	377 in	71,253 in-lb	142,506 in-lb
15	8	189 lb	407 in	76,923 in-lb	219,429 in-lb
16	8	189 lb	407 in	76,923 in-lb	296,352 in-lb
17	9	189 lb	436 in	82,404 in-lb	378,756 in-lb
18	9	189 lb	436 in	82,404 in-lb	461,160 in-lb
19	9	189 lb	436 in	82,404 in-lb	543,564 in-lb

TABLE 3-12. COMPARISON OF MOMENTS FOR ZONE 3

Passenger No.	Cumulative Moment from the Zone Centroid Assumption	Cumulative Moment from the Window-Aisle-Remaining Assumption	Difference
13	77,679 in-lb	71,253 in-lb	-6,426 in-lb
14	155,358 in-lb	142,506 in-lb	-12,852 in-lb
15	233,037 in-lb	219,429 in-lb	-13,608 in-lb
16	310,716 in-lb	296,352 in-lb	-14,364 in-lb
17	388,395 in-lb	378,756 in-lb	-9,639 in-lb
18	466,074 in-lb	461,160 in-lb	-4,914 in-lb
19	543,753 in-lb	543,564 in-lb	-189 in-lb

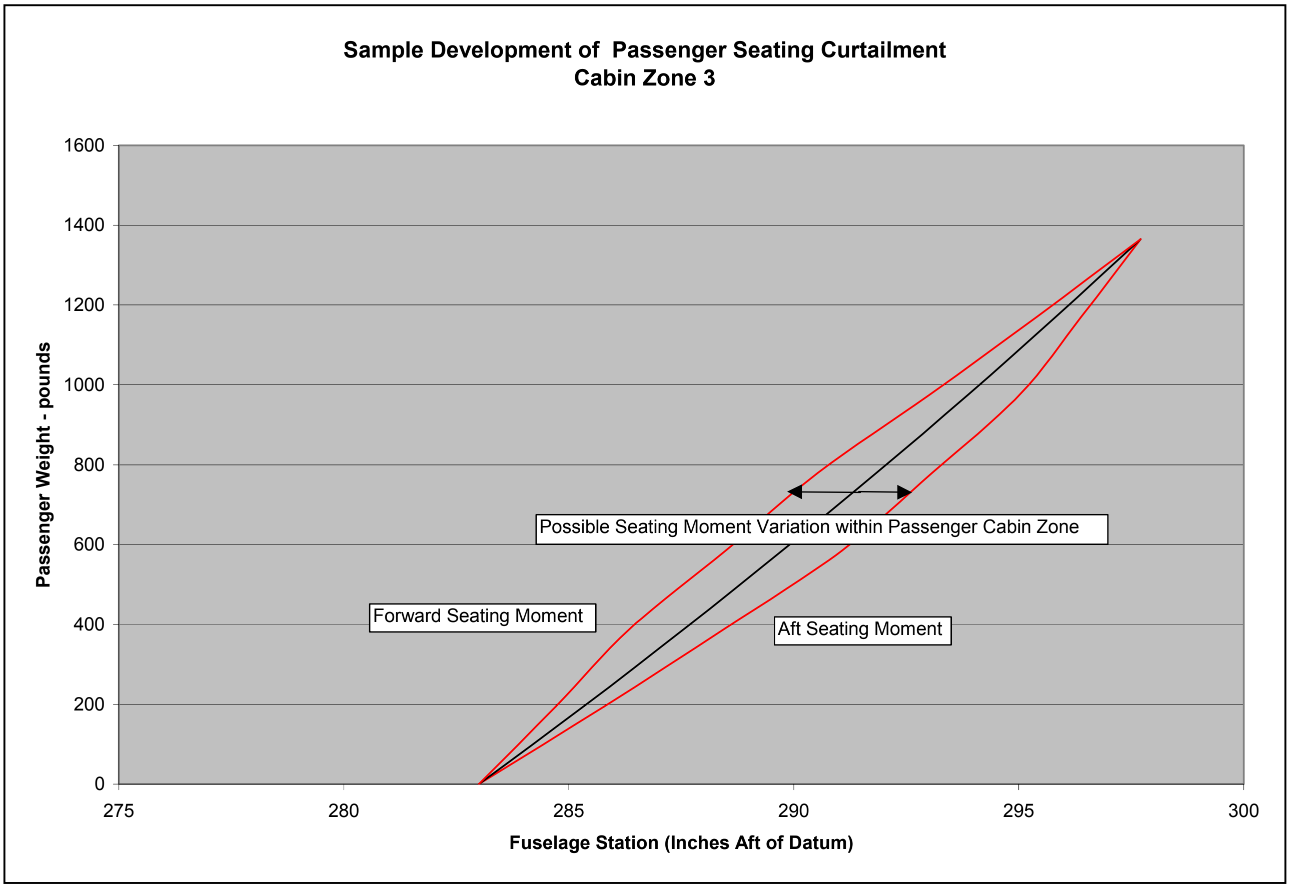


FIGURE 3-4. SAMPLE PASSENGER SEATING MOMENT (ZONE 3)

(4) Determining the most adverse loading. It is important that an operator examine the above results (from Tables 3-4 through 3-12) for each zone and determine which loading scenario results in the greatest difference in moments. For zones 1 and 2, having two, three, or four passengers in the zone results in the largest difference between the moments. For zone 3, having four passengers in the zone results in the largest difference. In this case, the operator should curtail the manufacturer's loading envelope forward and aft by the sum of these moments, 36,666 inch-pounds, to account for the potential variation in passenger seating. In this example, the 36,666 inch-pounds is the sum of 11,340 from Table 3-6; 10,962 from Table 3-9; and 14,364 from Table 3-12.

(5) Using actual seating location. Alternatively, an operator may reasonably avoid the above curtailment calculations by determining the actual seating location of each passenger in the cabin. By eliminating potential variation in passenger seating, an operator would not need to make assumptions about passenger seating and would not need to curtail the loading envelope accordingly. An operator choosing to use actual seating location should have procedures in place to ensure that passengers sit in their assigned location.

4. Other Curtailments to the Manufacturer's Loading Envelope.

a. Variation in passenger weight. Because the operator in this example elects to use standard average weights on a small-cabin aircraft, an additional curtailment for potential variation in passenger weight is required. The operator should curtail the manufacturer's loading envelope as described in Appendix 4.

b. Variation in fuel density. Because the loading of fuel does not significantly change the CG of the aircraft, the operator would not need to provide a curtailment for variation in fuel density.

c. Fuel movement in flight. For this sample aircraft, the manufacturer has considered the movement of fuel in flight. Therefore, the operator does not need to include additional curtailments in the operational loading envelope.

d. Fluids. The sample aircraft does not have a lavatory or catering.

e. Bags and freight. The sample aircraft has an aft bag compartment split into two sections. If the operator has procedures in place to restrict the movement of bags between the two sections, no additional curtailment to the envelope is required.

f. In-flight movement of passengers and crewmembers. Because there are no flight attendants and the aircraft is not equipped with a lavatory, it is reasonable to assume that passengers or crewmembers will not move about the cabin in flight.

g. Movement of flaps and landing gear. The manufacturer of the sample aircraft has considered the movement of flaps and landing gear in the development of its loading envelope. The operator does not need to include any additional curtailments in its operational loading envelope for the movement of those items.

h. Fuel consumption. The fuel vector for the sample aircraft provides a small aft movement that requires a -8,900 inch-pounds curtailment to the aft zero fuel weight limits to ensure the aircraft does not exceed the aft limit as fuel is burned. This equates to a -0.8 inch curtailment at an estimated operational empty weight of 11,000 pounds with a linear transition to a -0.6 inch curtailment at maximum zero fuel weight (MZFW) of 16,155 pounds. In this example, the 8,900 inch-pounds is the fuel burn deviation that would bring the aircraft outside the aft CG limit during the course of flight.

5. Operational Loading Envelope Diagrams.

a. Figure 3-5 below shows the operator's curtailments to the manufacturer's loading envelope, based on the assumptions made about variations in passenger seating and weight, as well as fuel consumption.

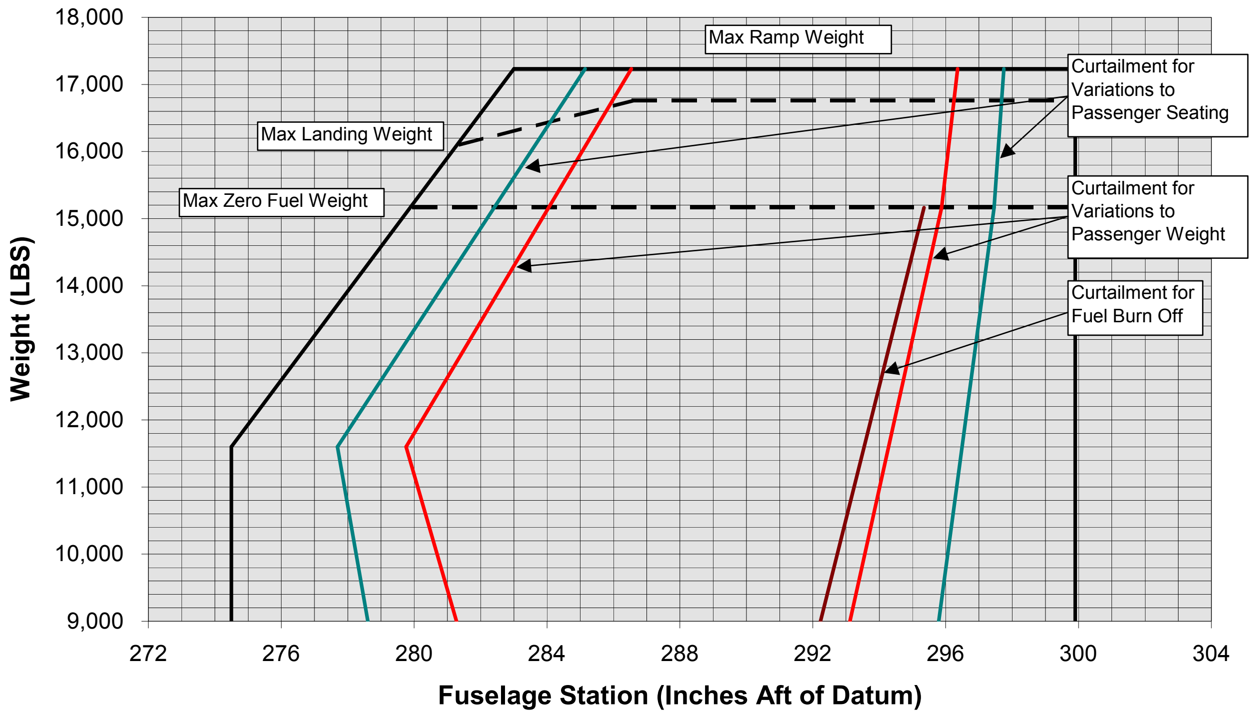


FIGURE 3-5. OPERATIONAL LOADING ENVELOPE WITH A CURTAILMENT FOR VARIATIONS IN PASSENGER SEATING

b. To expand the operational loading envelope, an operator could choose to use the actual seating location of passengers in the cabin and reduce the curtailment for variations in passenger seating. Figure 3-6 below shows the expansion of the operational loading envelope.

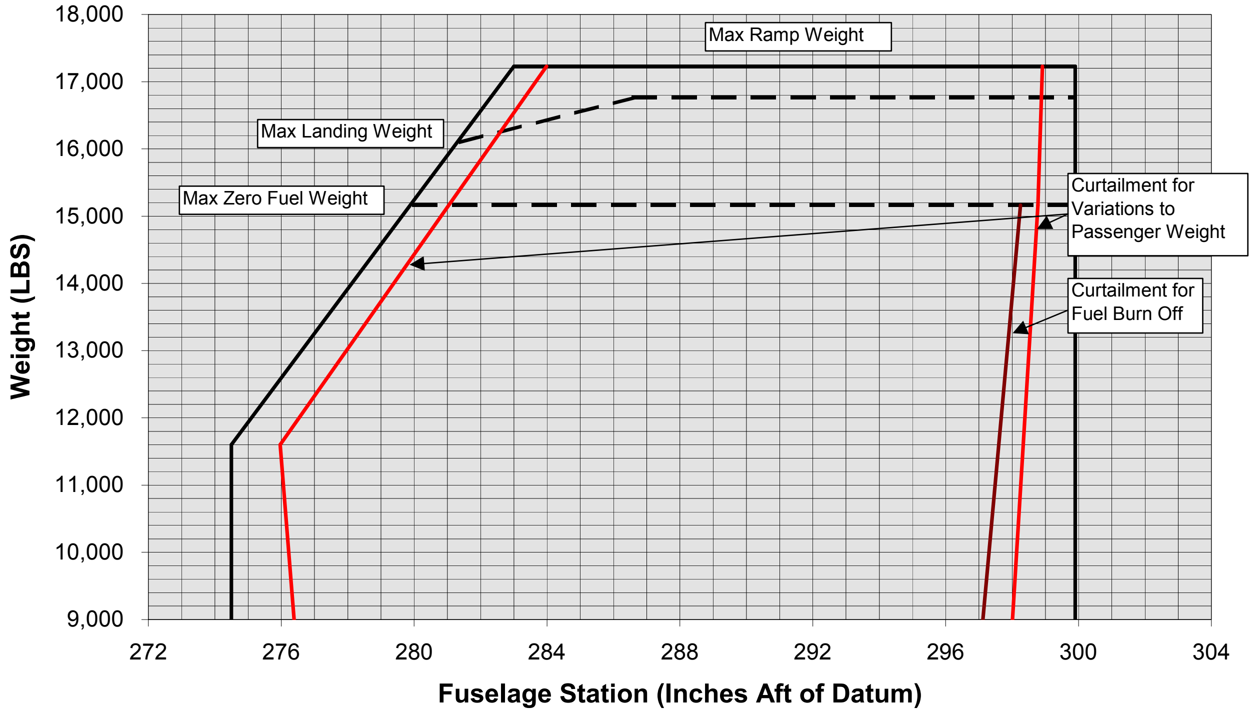


FIGURE 3-6. OPERATIONAL LOADING ENVELOPE USING ACTUAL SEATING LOCATION OF PASSENGERS

APPENDIX 4. ADDITIONAL CURTAILMENT TO CG ENVELOPES FOR PASSENGER WEIGHT VARIATIONS IN SMALL CABIN AIRCRAFT

a. The use of average weights for small cabin aircraft requires consideration of an additional curtailment to the center of gravity (CG) envelope for passenger weight variations and male/female passenger ratio. This curtailment is in addition to the standard curtailments discussed in Chapter 1 with examples in Appendix 3.

(1) Passenger weight variation is determined by multiplying the standard deviation (from the source of the average passenger weight used) by the row factor from Table 4-1. The following table is a statistical measure that ensures a 95-percent confidence level of passenger weight variation, using the window-aisle-remaining seating method.

TABLE 4-1. ROW FACTOR

No. of Rows	2-abreast	3-abreast	4-abreast
2	2.96	2.73	2.63
3	2.41	2.31	2.26
4	2.15	2.09	2.06
5	2.00	1.95	1.93
6	1.89	1.86	1.84
7	1.81	1.79	1.77
8	1.75	1.73	1.69
9	1.70	1.68	1.65
10	1.66	1.65	1.62
11	1.63	1.59	1.59
12	1.60	1.57	1.57
13	1.57	1.54	1.54
14	1.55	1.52	1.52
15	1.53	1.51	1.51
16	1.49	1.49	1.49
17	1.48	1.48	1.48
18	1.46	1.46	1.46

(2) Protect against the possibility of an all-male flight by subtracting the difference between the male and average passenger weight.

(3) The sum of these two provides an additional weight to be used for CG curtailment, similar to the way in which passenger seating variation is calculated.

b. Calculation of the curtailment passenger weight variation is decided by multiplying the standard deviation by the correction factor and adding the difference between the average all-male and average passenger weight. For example, assuming a 47-pound standard deviation, the difference between the average all-male and average passenger weight is 10 pounds (from 1999–2000 National Health and Nutrition Examination Survey (NHANES) data), and a sample aircraft with 9 rows in a 2-abreast configuration. The additional weight to be curtailed is determined as:

Weight for Additional Curtailment = (47 × 1.70) + (10) = 90 lb

c. For the example, the additional curtailment should be accomplished by assuming passenger loading at 90 pounds using the program method for passenger seating variation (e.g., window-aisle-remaining). Using the window-aisle-remaining method, the additional curtailment in the example is determined to be 59,031 inch-pounds forward and aft. Table 4-2 displays the calculations used in this example.

TABLE 4-2. SAMPLE CURTAILMENT DUE TO VARIATIONS IN PASSENGER WEIGHT AND MALE/FEMALE RATIO USING WINDOW-AISLE METHOD

Passenger Weight: 90 Coach Class (Y) Cabin Centroid: 323.8

Forward Seating						Aft Seating					
Row	Seat Centroid	Seat Moment	Total Weight	Total Moment	Moment Deviation	Row	Seat Centroid	Seat Moment	Total Weight	Total Moment	Moment Deviation
1	198.0	17,820	90	17,820	-11,321	9	436.0	39,240	90	39,240	10,099
1	198.0	17,820	180	35,640	-22,642	9	436.0	39,240	180	78,480	20,198
2	228.0	20,520	270	56,160	-31,263	9	436.0	39,240	270	117,720	30,297
2	228.0	20,520	360	76,680	-39,884	8	407.0	36,630	360	154,350	37,786
3	258.0	23,220	450	99,900	-45,805	8	407.0	36,630	450	190,980	45,275
3	258.0	23,220	540	123,120	-51,726	7	377.0	33,930	540	224,910	50,064
4	289.0	26,010	630	149,130	-54,857	7	377.0	33,930	630	258,840	54,853
4	289.0	26,010	720	175,140	-57,988	6	347.0	31,230	720	290,070	56,942
5	318.0	28,620	810	203,760	-58,509	6	347.0	31,230	810	321,300	59,031
5	318.0	28,620	900	232,380	-59,031	5	318.0	28,620	900	349,920	58,509
6	347.0	31,230	990	263,610	-56,942	5	318.0	28,620	990	378,540	57,988
6	347.0	31,230	1,080	294,840	-54,853	4	289.0	26,010	1,080	404,550	54,857
7	377.0	33,930	1,170	328,770	-50,064	4	289.0	26,010	1,170	430,560	51,726
7	377.0	33,930	1,260	362,700	-45,275	3	258.0	23,220	1,260	453,780	45,805
8	407.0	36,630	1,350	399,330	-37,786	3	258.0	23,220	1,350	477,000	39,884
8	407.0	36,630	1,440	435,960	-30,297	2	228.0	20,520	1,440	497,520	31,263
9	436.0	39,240	1,530	475,200	-20,198	2	228.0	20,520	1,530	518,040	22,642
9	436.0	39,240	1,620	514,440	-10,099	1	198.0	17,820	1,620	535,860	11,321
9	436.0	39,240	1,710	553,680	0	1	198.0	17,820	1,710	553,680	0

NOTE: The following definitions describe the parameters used in the samples in Tables 4-2 and 4-3:

- Seat Centroid: Location of passenger weight at seat
- Seat Moment: Additional passenger weight × seat centroid
- Total Weight: Sum of additional passenger weights (running total)
- Total Moment: Sum of additional passenger moments
- Moment Deviation: Difference between total moment and moment generated by assuming additional passenger weight is located at the cabin centroid (323.8 in)

d. If the operator chooses to use the passenger cabin zone concept (as described in Appendix 3) and apply this concept to account for variation in passenger weight, then the row factor in Table 4-1 corresponding to the number of rows in each zone should be used.

(1) Considering three cabin zones with each zone containing three rows in a 2-abreast configuration, the required row factor (see Table 4-1) is 2.41. The row factor is multiplied by the standard deviation and the difference between average all-male and average passenger weights is added to provide the additional weight consideration. In our example, the standard deviation is calculated from the National Health and Nutrition Examination Survey (NHANES) data as 47 pounds, and the difference between average all-male and average passenger weights is 10 pounds. The resulting additional weight for curtailment is $47 \times 2.41 + 10 = 123$ pounds. This additional weight is applied per the window-aisle-remaining concept for each cabin zone independently and the results are summed to determine the amount of curtailment. In this case, the curtailment is found to be 23,791 inch-pounds forward and aft.

(2) If an operator chooses to use row count, the operator must use the row factor for two rows. In this example the required row factor is 2.96 (see Table 4-1). The row factor is multiplied by the standard deviation and the difference between average all-male and average passenger weight is added to provide the additional weight consideration. In our example, the standard deviation is calculated from the NHANES data as 47 pounds, and the difference between average all-male and average passenger weights is 10 pounds. The resulting additional weight for curtailment is $47 \times 2.96 + 10 = 149$ pounds. This additional weight is applied as if a two-row passenger zone concept is used for passenger seating. The resulting curtailment is determined to be 17,880 inch-pounds forward and aft (see Table 4-3).

TABLE 4-3. SAMPLE CURTAILMENT DUE TO VARIATIONS IN PASSENGER WEIGHT AND MALE/FEMALE RATIO USING ROW COUNT METHOD

Coach Class (Y) Cabin Centroid (Rows 1-2): 213.0
Coach Class (Y) Cabin Centroid (Rows 3-4): 273.5
Coach Class (Y) Cabin Centroid (Rows 5-6): 332.5
Coach Class (Y) Cabin Centroid (Rows 7-8): 392.0
Passenger Weight: 149 Coach Class (Y) Cabin Centroid (Row 9): 436.0

Forward Seating						Aft Seating					
Row	Seat Centroid	Seat Moment	Total Weight	Total Moment	Moment Deviation	Row	Seat Centroid	Seat Moment	Total Weight	Total Moment	Moment Deviation
1	198.0	29,502	149	29,502	-2,235	9	436.0	64,964	149	64,964	0
1	198.0	29,502	298	59,004	-4,470	9	436.0	64,964	298	129,928	0
2	228.0	33,972	447	92,976	-2,235	9	436.0	64,964	447	194,892	0
2	228.0	33,972	596	126,948	0	8	407.0	60,643	149	60,643	2,235
3	258.0	38,442	149	38,442	-2,310	8	407.0	60,643	298	121,286	4,470
3	258.0	38,442	298	76,884	-4,619	7	377.0	56,173	447	177,459	2,235
4	289.0	43,061	447	119,945	-2,310	7	377.0	56,173	596	233,632	0
4	289.0	43,061	596	163,006	0	6	347.0	51,703	149	51,703	2,161
5	318.0	47,382	149	47,382	-2,161	6	347.0	51,703	298	103,406	4,321
5	318.0	47,382	298	94,764	-4,321	5	318.0	47,382	447	150,788	2,161
6	347.0	51,703	447	146,467	-2,161	5	318.0	47,382	596	198,170	0
6	347.0	51,703	596	198,170	0	4	289.0	43,061	149	43,061	2,310
7	377.0	56,173	149	56,173	-2,235	4	289.0	43,061	298	86,122	4,619
7	377.0	56,173	298	112,346	-4,470	3	258.0	38,442	447	124,564	2,310
8	407.0	60,643	447	172,989	-2,235	3	258.0	38,442	596	163,006	0
8	407.0	60,643	596	233,632	0	2	228.0	33,972	149	33,972	2,235
9	436.0	64,964	149	64,964	0	2	228.0	33,972	298	67,944	4,470
9	436.0	64,964	298	129,928	0	1	198.0	29,502	447	97,446	2,235
9	436.0	64,964	447	194,892	0	1	198.0	29,502	596	126,948	0

Sum of Minimum Moment Deviations -17,880
Sum of minimum Moment Deviations -17,880

Sum of Maximum Moment Deviations 17,880
Sum of maximum Moment Deviations 17,880

APPENDIX 5. OPTIONS TO IMPROVE ACCURACY

A number of options are available that enable operators to deviate from standard assumed weights and may also provide relief from constraints required when assumed averages are used. These options include:

1. Surveys. Surveys may be accomplished for passenger weights (to include carry-on bags), checked baggage weights, male/female ratios, and fuel densities. These surveys may be conducted for entire operator route systems, or by specific market or region. Surveys practices and data reduction must conform to the requirements defined in this advisory circular (AC). Use of surveys may allow an operator to use passenger and baggage weights less than the standard specified in this AC. Also, a survey may find that the assumed male/female ratio is incorrect and appropriate adjustments must be made. For example, let's assume the following results from an approved passenger and baggage survey.

Male passenger weight (M) = 183.3 pounds
Female passenger weight (F) = 135.8 pounds
Difference between male and average passenger weights = 24.0 pounds
Standard deviation of total sample (Sigma) = 47.6 pounds
Male/female ratio (Pax Ratio) = 50.6 percent
Checked baggage weight = 29.2 pounds
Baggage checked plane-side = 21.3 pounds
Carry-on and personal items weight (CO Wt) = 10.4 pounds
Carry-on and personal items per passenger ratio (CO Ratio) = 0.82 pounds
Survey conducted in summer months

The resulting assumed passenger weight for loading is expressed as:

Passenger Weight = (M × Pax Ratio) + (F × (1 - Pax Ratio)) + (CO Wt × CO Ratio)

And is determined as:

Summer Passenger Weight = (183.3 × 0.506) + (135.8 × (1 - 0.506)) + (10.4 × 0.82) = 169 lb

Winter Passenger Weight = 169 + 5 = 174 lb

Survey results would also be used to determine the additional curtailment for variations to passenger weight. Assuming a 19-seat aircraft in 2-abreast configuration in our example, the additional weight to be curtailed would be:

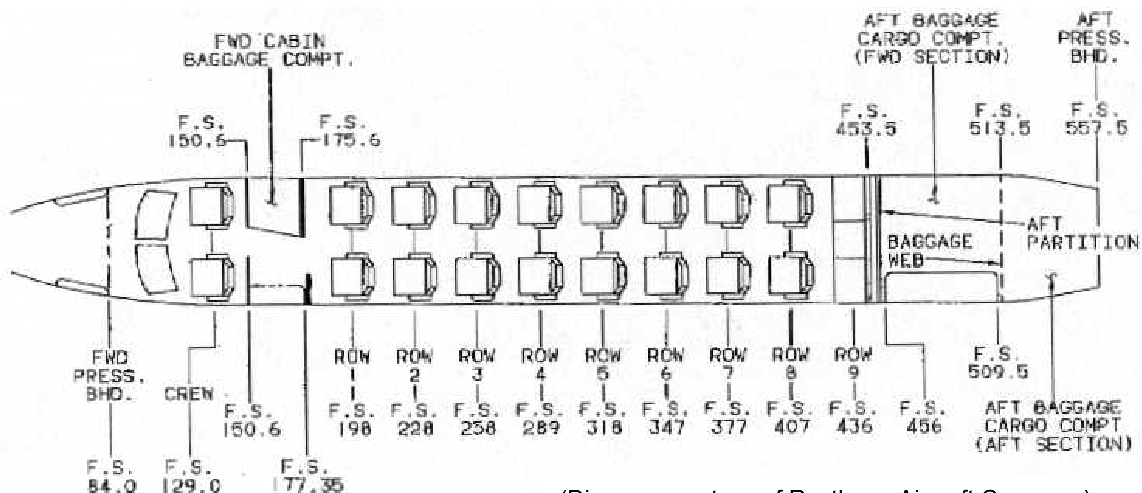
Additional Weight for Curtailment = (47 × 1.70) + 24 = 104 lb

Also in our example, the assumed checked baggage weight is 30 pounds. Plane-side loaded bags would be assumed to weigh 20 pounds. (These weights are the standard average weights provided for a no-carry-on baggage program as described in Chapter 2, Section 2).

2. Actual Weights. It is permissible to use actual weights in lieu of standard average, segmented, or survey-derived average weights (if applicable). Parameters that may use actual weights include passenger weights, checked baggage weights, carry-on bag weights, crew weights, and fuel density/weight.

3. Passenger Cabin Zones and Row Count. Passenger cabins may be split up into zones provided an acceptable procedure for determination of passenger seating is included (e.g., use of seat assignments or the crew counts each seated passengers by zone). If zones are used, it may be reasonable for the operator to reduce the center of gravity (CG) passenger seating curtailment by accommodating variations within each individual zone separately and totaling the results. Passenger row count allows the operator to reduce the seating variation by accounting for the row in which the passenger is actually seated.

An example of use of passenger zones follows.
Assume an aircraft interior as displayed in Figure 5-1.



(Diagram courtesy of Raytheon Aircraft Company)

FIGURE 5-1. SAMPLE AIRCRAFT INTERIOR SEATING DIAGRAM

Assume that for weight and balance purposes, it is desirable to break up the cabin into passenger zones. Appendix 3 provides a sample calculation of curtailing for passenger seating variations using a hypothetical commuter category 19-seat aircraft with 3 passenger zones. A more accurate weight and balance calculation requiring less curtailment may be provided by increasing the number of passenger zones. For example, an increase to 5 passenger zones would result in the following:

The passenger zones will be determined as zone 1 (rows 1–2), zone 2 (rows 3–4), zone 3 (rows 5–6), zone 4 (rows 7–8), and zone 5 (row 9). Use of the window-aisle-remaining method will be used in each zone to provide a total curtailment to the CG envelope. (For this sample aircraft, window-aisle-remaining method simply becomes forward and aft end loading). For each zone, a zone centroid must be calculated by counting the total number of seats and averaging their location.
Zone 1 centroid = (2 x 198.0 + 2 x 228.0) / (2 + 2) = 213.0 in
Zone 2 centroid = (2 x 258.0 + 2 x 289.0) / (2 + 2) = 273.5 in
Zone 3 centroid = (2 x 318.0 + 2 x 347.0) / (2 + 2) = 332.5 in
Zone 4 centroid = (2 x 347.0 + 2 x 377.0) / (2 + 2) = 392.0 in
Zone 5 centroid = (3 x 436.0) / (3) = 436.0 in

Assuming the standard winter passenger weight of 189 pounds (as determined in Appendix 3) is used in the curtailment, the calculation of the total moment is required for comparison to the zone moment, assuming each passenger is seated at the centroid of each passenger zone. The total moment is found by summing the individual moments calculated at each occupied seat in the window-aisle-remaining progression.

Forward Curtailment Calculations— Zone 1

Pax	Row	Arm	Total Moment	Zone Centroid	Zone Moment	Delta Moment
1	1	198.0	37,422	213.0	40,257	-2,835
2	1	198.0	74,844	213.0	80,514	-5,670
3	2	228.0	117,936	213.0	120,771	-2,835
4	2	228.0	161,028	213.0	161,028	0

Forward Curtailment Calculations—Zone 2

Pax	Row	Arm	Total Moment	Zone Centroid	Zone Moment	Delta Moment
1	3	258.0	48,762	273.5	51,692	-2,930
2	3	258.0	97,524	273.5	103,383	-5,859
3	4	289.0	152,145	273.5	155,075	-2,930
4	4	289.0	206,766	273.5	206,766	0

Forward Curtailment Calculations—Zone 3

Pax	Row	Arm	Total Moment	Zone Centroid	Zone Moment	Delta Moment
1	5	318.0	60,102	332.5	62,843	-2,741
2	5	318.0	120,204	332.5	125,685	-5,481
3	6	347.0	185,787	332.5	188,528	-2,741
4	6	347.0	251,370	332.5	251,370	0

Forward Curtailment Calculations—Zone 4

Pax	Row	Arm	Total Moment	Zone Centroid	Zone Moment	Delta Moment
1	7	377.0	71,253	392.0	74,088	-2,835
2	7	377.0	142,506	392.0	148,176	-5,670
3	8	407.0	219,429	392.0	222,264	-2,835
4	8	407.0	296,352	392.0	296,352	0

Forward Curtailment Calculations—Zone 5

Pax	Row	Arm	Total Moment	Zone Centroid	Zone Moment	Delta Moment
1	9	436.0	82,404	436.0	82,404	0
2	9	436.0	164,808	436.0	164,808	0
3	9	436.0	247,212	436.0	247,212	0

The curtailment for passenger seating variation is determined by adding the largest delta moments from each of the passenger zones. In our example, the curtailment to the forward CG limit for passenger seating variation is -22,680 inch-pounds (-5,670 + -5,859 + -5,481 + -5,670 + 0). Similarly, the curtailment to the aft limit of the CG envelope using the window-aisle-remaining method loading from the most aft seat row moving forward (in each zone) would result in an adjustment of +22,680 inch-pounds. These curtailments compare favorably to the curtailments of ± 36,666 inch-pounds determined in the sample provided for three passenger zones in Appendix 3.

4. Actual Male/Female Counts. Loading systems may use separate male and female assumed passenger weights for each operation. If the operator's weight and balance program is approved for use of male/female weights, then the operator must count the number of male passengers and female passengers separately. The male and female weights used may be from the development of standard passenger weight or they may be determined through an operator-developed survey. Use of male/female weights may be for entire operations or for a particular route and/or region of flying.

An example of how male/female ratios can be applied to weight and balance systems follows. Assuming the operator is using the survey results as described in subparagraph (1) above, the assumed male and female passenger weights, including average carry-on baggage, are computed as:

Male passenger weight (summer) = $183.3 + 10.4 \times 0.82 = 192$ lb
Male passenger weight (winter) = $192 + 5 = 197$ lb
Female passenger weight (summer) = $135.8 + 10.4 \times 0.82 = 144$ lb
Female passenger weight (winter) = $144 + 5 = 149$ lb

The weight and balance manifest would provide for identification of male/female identification and the passenger weights would be summed accordingly. For instance, 7 male and 11 female passengers would result in a total passenger weight of $(7 \times 192) + (11 \times 144) = 2{,}928$ pounds.

5. Adolescent (Child) Weights. In most circumstances, an operator may consider any passenger who is less than 13 years of age and is occupying a seat to weigh less than an adult passenger. The standard average adolescent child weights can be found in Table 2-1 of Chapter 2.

6. Standard Weights with Approved No-carry-on Baggage Program.

Summer Passenger Weight = 184 lb
Winter Passenger Weight = 189 lb
Checked Baggage Weight = 30 lb each
Baggage Checked Plane-side = 20 lb each

Inclusion in the no-carry-on baggage program does not preclude use of actual or surveyed weights for passengers, carry-on/personal items, checked baggage, or baggage checked plane-side.

7. Automation. Automation may also be used to provide a more accurate weight and balance program. Examples of automation include use of seat assignments for the determination of passenger moment and historical seating to determine passenger moment.

APPENDIX 6. WEIGHT AND BALANCE CHECKLIST

- ❑ What operators should use this AC? Refer to paragraph 5 on page ii.

- ❑ Does the operator use individual aircraft Operating Empty Weights (OEW) or Fleet OEWs? Refer to paragraph 102.

- ❑ Does the operator have an individual aircraft weighing program or a fleet weighing program? Refer to paragraph 103.

- ❑ Each operator must construct a loading envelope with curtailments. Refer to Chapter 1, Sections 2 and 3.

- ❑ What is the aircraft cabin size? Refer to paragraph 5b and Table 1 on page ii.

a. If the aircraft is a large cabin aircraft, then refer to paragraph 200d:

❑ **Large Cabin Aircraft**

1. For standard average weights, refer to Chapter 2, Section 2.
2. For survey-derived average weights, refer to Chapter 2, Section 3.
3. For actual weight programs refer to Chapter 2, Section 5.
4. For segmented weights refer to Chapter 2, Section 4.

b. If the aircraft is a medium cabin aircraft, then refer to paragraph 200e:

❑ **Medium Cabin Aircraft Treated as Large**

1. See Large Cabin Aircraft items 1–4 above, and
2. If operator has a no-carry-on bag program, refer to paragraph 205.

❑ **Medium Cabin Aircraft Treated as Small**

1. See Small Cabin Aircraft items 1–2 below.

c. If the aircraft is a small cabin aircraft, then refer to paragraph 200f:

❑ **Small Cabin Aircraft**

1. If the aircraft meets the performance criteria stated in paragraph 200f(3)(a),
   a. Refer to Chapter 2, Section 2 for standard average weights and Appendix 4 for additional CG envelope curtailment, or
   b. Refer to Chapter 2, Section 3 for survey-derived average weights and Appendix 4 for additional CG envelope curtailment.
   c. If operator has a no-carry-on bag program, refer to paragraph 205.

2. If the aircraft does not meet the performance criteria stated in paragraph 200f(3)(a), or the operator elects to use actual or segmented weights, then:
   a. For actual weight programs refer to Chapter 2, Section 5.
   b. For segmented weights refer to Chapter 2, Section 4.
   c. If operator is using segmented weights and has a no-carry-on bag program refer to paragraph 205.