Presentation

Getting to Know AC 120-27F

FAA Guidance for Weight & Balance Control

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Introduction

Tom Tanner

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Agenda

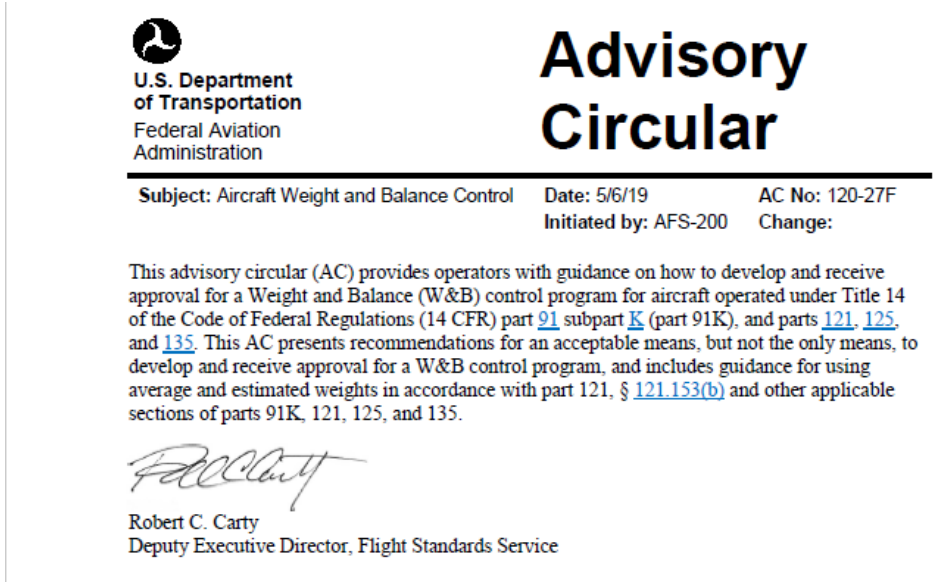
- **Introduction and Purpose**
- **What is AC-120-27F?**
- **Chapter 1 – Overview**
- **Chapter 2 – Overview**
- **Chapter 3 – Overview**
- **Chapter 4 – Overview**
- **Appendix C – Example**
- **Closing Remarks / Questions**

Introduction and Purpose

- **Welcome to the exciting world of FAA Aircraft Circulars and Regulations**
  - **We will be diving into AC-120-27F to get a basic understanding of the AC's guidance.**
  - **This presentation will give you general knowledge of the AC.**
  - **I highly recommend everyone take time to fully read AC-120-27F.**
  - **For supplemental information with examples of concepts covered in this AC refer to Weight & Balance Handbook FAA-H-8083-1B**

What Is AC-120-27F?

- **AC-120-27F**
  - **An Aircraft Circular is a document published by the FAA to provide guidance and information associated with compliance, training, standards or special topics.**
  - **AC-120-27F provides guidance on how to develop and receive approval for a Weight and Balance control program for aircraft operated under part 91K, parts 121, 125 and 135.**



U.S. Department of Transportation
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Advisory Circular

Subject: Aircraft Weight and Balance Control | **Date:** 5/6/19 | **AC No:** 120-27F
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This advisory circular (AC) provides operators with guidance on how to develop and receive approval for a Weight and Balance (W&B) control program for aircraft operated under Title 14 of the Code of Federal Regulations (14 CFR) part 91 subpart K (part 91K), and parts 121, 125, and 135. This AC presents recommendations for an acceptable means, but not the only means, to develop and receive approval for a W&B control program, and includes guidance for using average and estimated weights in accordance with part 121, § 121.153(b) and other applicable sections of parts 91K, 121, 125, and 135.

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PDF Link:
https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1035868

What Is AC-120-27F?

- **Purpose of AC-120-27F**
  - **AC-120-27F provides operators with clarification and guidance on how to:**
    - **Develop and receive approval for a W&B control plans**
    - **Establish aircraft weight and loading schedules**
    - **Create operational limits and curtailments**
    - **Develop passenger and baggage weights and averages**
    - **Address operator reporting systems and oversight of W&B control program**

Chapter 1 Overview

- **AC-120-27F Chapter 1 – AC Purpose**
  - **The AC offers recommendations on developing a W&B control program.**
  - **A W&B control plan is required for aircraft under part 91K , and parts 121, 125, and 135 (Ref 1.2.1)**
  - **Operators under part 91K and 135 can create a W&B control plan or use actual or average aircraft, passenger, or baggage weights. (Ref 1.2.1)**
  - **Recommendations are tailored to aircraft cabin sizes:**

Table 1-1. Aircraft Cabin Size

For this AC, an aircraft originally 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.

  - **The operator is ultimately responsible for maintaining a safe weight and CG calculation method and must determine if this AC guidance is appropriate for their aircraft and type of operation.**
  - **<u>The overall purpose is to help operators calculate takeoff weights and CG as accurately as possible to insure safe adherence to aircraft certification limitations.</u>**

Chapter 1 – Standard Avg Weights Limitations

- **AC-120-27F – 1.7**

1.7 Who Can Use Standard Average Weights?

1.7.1 Standard Average Weights. Use of standard average weights is limited to operators of multiengine turbine-powered aircraft that have a passenger-seat configuration of 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 normal category; or the operator and manufacturer are able to prove that the aircraft can meet the performance requirements prescribed by part 23 normal category aircraft. Single-engine and multiengine turbine helicopter air ambulance (HAA) operators may also use standard average weights for emergency medical service (EMS) operations, provided they have received an LOA.

1.7.2 Use of Standard Average Weights. The FAA's recommendations and advice on the safe use of standard average weights are contained in this document. In the FAA's view, it would be unsafe for an aircraft operator to use standard average 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 normal category aircraft, may only use an actual weight. Normal category aircraft per part 23, § 23.2005 may use standard average weights and should see paragraph 3.1.1.6 for further guidance.

- **Limitations**
  - **Limitations are noted for smaller aircraft as weight and CG have less margin for error.**
  - **Operators with passenger capability of 5 or more may use averages, if operating under the correct certification requirements.**

Chapter 1 – Weight Control Program

- **W&B Control Plan**
  - **A W&B control plan is an operator's method of accomplishing the following tasks:**
    - **Safely maintain accurate Weight and CG of aircraft or fleet of aircraft**
    - **Document and perform interval aircraft weighing**
    - **Track and document weight changes**
    - **Document and develop an aircraft loading schedule**
    - **Document compliance to aircraft W&B limitations, including curtailment**
    - **Document and maintain passenger, baggage, and operational item average weights**
  - **The control plan must have approval and oversight through the operator's Principal Inspectors (PI) in the Certificate Management Office (CMO) or Flight Standards District Office (FSDO)**

Chapter 2 – Aircraft Weights and Loading Schedules

- **Establishing Aircraft Weight**
  - **Initial Weight and CG (Ref 2.1.1)**
    - **All aircraft need an initial actual weight and CG measurement**
  - **W&B Change Tracking (Ref 2.1.2)**
    - **Systems can vary. A log, ledger, proprietary electronic or off the shelf electronic means are acceptable.**
    - **Changes that should be recorded are:**

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

  - **Reweighing or calculation reestablishment should happen when the change log is more than (0.5%) the max landing weight or CG position exceeds (0.5%) the MAC. (Ref 2.1.3.1)**
    - **Helicopters and aircraft without a MAC based CG envelope should reestablish after a cumulative change of (0.5%) total CG range**

Chapter 2 – Aircraft Weighing Schedules - Individual

- **Individual Aircraft Weighing**
  - **Aircraft are normally weighed every 36 calendar-months. (Ref 2.1.4.1)**
    - **Aircraft can extend the interval with proper accounting and reestablishment but not exceed 48 calendar-months between weighing.**
    - **Part 125 aircraft cannot exceed 36 calendar-months weighing intervals.**
    - **Helicopters should not exceed the time equivalent to the overhaul period.**

Chapter 2 – Aircraft Weighing Schedules - Fleet

- **Fleet Aircraft Weighing**
  - **Operators with a multitude of similarly configured aircraft of the same model can weigh only a portion of their fleet every 36 months and apply those weight and CG changes back to the entire fleet. (Ref 2.1.4.2)**
  - **Fleet sampling should follow the following recommendations:**

Table 2-2. 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

  - **Averages of sampling results in weight and moments are applied to the remaining fleet. (Ref 2.1.4.2)**
  - **Aircraft with the most hours since last weighing to be weighed first. Operators must establish a time limit such that all aircraft are eventually weighed. (Ref 2.1.4.2.3)**
  - **Aircraft mods must be maintained per aircraft unless changes are fleet wide. If fleet wide calculation or reweigh sampling required. (Ref 2.1.4.3)**

Chapter 2 – Limitation of Fleet Weighing

- **Limitations of Fleet Weighing (Ref 2.1.4.2.1)**
  - **Aircraft must be same type. Example 737-200 and 737-300 can not share a fleet W&B.**
  - **Aircraft of same type must have similar if not same interior layout. Example: Business jet fleet with same model aircraft but Aft vs. Fwd galley interior layouts are not compatible.**

737-200

737-300

Not compatible for Fleet Weighing!

Chapter 2 – Aircraft Loading Schedules

- **Aircraft Loading Schedules (Ref 2.2.1)**
  - **Loading schedules are developed by the operator to document compliance to certified W&B limits.**
  - **The following aircraft manufacturer limits must be used (Ref 2.3.2)**
    - **Max Zero Fuel Weight / Max Takeoff Weight / Max Taxi Weight / Takeoff and Landing CG limits / Max Floor Loadings / Max Compartment Weights / Fuselage Shear Limits / Any Additional Limitations.**

Passenger Loading Table

# of passengers	Weight (lb)	Moment/1,000
Forward compartment centroid—582.0		
5	850	495
10	1,700	989
15	2,550	1,484
20	3,400	1,979
25	4,250	2,473
29	4,930	2,869
Aft compartment centroid—1,028.0		
10	1,700	1,748
20	3,400	3,495
30	5,100	5,243
40	6,800	6,990
50	8,500	8,738
60	10,200	10,486
70	11,900	12,233
80	13,600	13,980
90	15,300	15,728
100	17,000	17,476
110	18,700	19,223
120	20,400	20,971
133	22,610	23,243

Cargo Loading Table

	Moment/1,000	
Weight (lb)	Forward hold arm—680.0	Aft hold arm—1,166.0
6,000		6,966
5,000	3,400	5,830
4,000	2,720	4,664
3,000	2,040	3,498
2,000	1,360	2,332
1,000	680	1,166
900	612	1,049
800	544	933
700	476	816
600	408	700
500	340	583
400	272	466
300	204	350
200	136	233
100	68	117

Fuel Loading Table

Tanks 1 and 3 (each)			Tank 2 (3 cells)					
Weight (lb)	Arm	Moment/1,000	Weight (lb)	Arm	Moment/1,000	Weight (lb)	Arm	Moment/1,000
8,500	992.1	8,433	8,500	917.5	7,799	22,500	914.5	20,576
9,000	993.0	8,937	9,000	917.2	8,255	23,000	914.5	21,034
9,500	993.9	9,442	9,500	917.0	8,711	23,500	914.4	21,488
10,000	994.7	9,947	10,000	916.8	9,168	24,000	914.3	21,943
10,500	995.4	10,451	10,500	916.6	9,624	24,500	914.3	22,400
11,000	996.1	10,957	11,000	916.5	10,082	25,000	914.2	22,855
11,500	996.8	11,463	11,500	916.3	10,537	25,500	914.2	23,312
12,000	997.5	11,970	12,000	916.1	10,993	26,000	914.1	23,767
						26,500	914.1	24,244
Full capacity			**(see note at lower left)			27,000	914.0	24,678
			18,500	915.1	16,929	27,500	913.9	25,132
** Note: Computations for Tank 2 weights for 12,500 lb to 18,000 lb have been purposely omitted.			19,000	915.0	17,385	28,000	913.9	25,589
			19,500	914.9	17,841	28,500	913.8	26,043
			20,000	914.9	18,298	29,000	913.7	26,497
			20,500	914.8	18,753	29,500	913.7	26,954
			21,000	914.7	19,209	30,000	913.6	27,408
			21,500	914.6	19,664			
			22,000	914.6	20,121	Full capacity		

Figure 9-5. *Loading schedule for determining weight and CG.*

Chapter 2 – Curtailment

- **Curtailment (Ref 2.3.3)**
  - **Curtailment is used to account for loading variations and in-flight movements as they relate to the manufacturer’s loading limitations.**
  - **Curtailments may be set for various stages of operation: taxi, takeoff, in-flight, and landing for example.**
  - **Curtailment creates operations envelopes that must account for variations in CG (passenger movement) or weight (delta to average weights) to ensure overall compliance to the certified envelope.**
  - **Aircraft manufacturers can support operators by providing guidance and supplemental information but are not required to do so.**

Chapter 2 – Curtailment - Passengers

- **Passenger related curtailments (Ref 2.3.4.1)**
  - **Passenger Cabin Distribution**
    - **Assigned seating**
    - **Non-uniform seating**
    - **Zone seating**
  - **Passenger Movement**
    - **Reasonable passenger movement – assigned seats**
    - **Passenger movement – unassigned seats**
  - **Crew Movement (Ref 2.3.4.4)**
    - **Crew services – Attendants and Cart**
    - **Cockpit crew movement**

Chapter 2 – Curtailment – Fuel and Fluids

- **Fuel related curtailments (Ref 2.3.4.2)**
  - **Fuel Density**
    - **Temperature**
  - **Fuel Movement**
    - **Maneuver related movement**
    - **Fuel Transfer**
  - **Fuel Usage (Burn)**
    - **In flight CG movement**
  - **Fluids (Ref 2.3.4.3)**
    - **Potable water in flight**
    - **Movement of water or lavatory fluids**

Chapter 2 – Onboard W&B Systems

- **Onboard W&B Systems (Ref 2.4)**
  - **Onboard W&B Systems can be used with FAA approval**
  - **Curtailment should still be used with onboard W&B Systems. No curtailment would be needed for passenger and baggage weight or distribution.**
  - **FAA approval of Onboard W&B Systems**
    - **System Calibration procedures and schedules**
      - **Onboard W&B Systems cannot be used to determine BEW in actual aircraft weighing**
      - **Operators are responsible for maintaining accuracy of the system**
        - **Supplemental safety checks are recommended**
    - **System accuracy must be demonstrated through a calibrated test**

Chapter 2 – Onboard W&B Systems Considerations

- **Onboard W&B Systems Operator Considerations (Ref 2.4.3)**
  - **Certification limitation checks and procedures**
  - **Environmental considerations – temp, barometric pressure, wind, slope, rain, ice…**
  - **Aircraft Considerations**
    - **No effects due to feather movement, doors, stairways, or any connection to ground service equipment**
    - **Engine thrust, oleo strut extension, aircraft taxi movement**
  - **Takeoff trim settings**
  - **Operational envelope development**
  - **Develop methods for floor, linear or running load limit compliance**

Chapter 3 – Methods to Determine the Weight of Passengers

- **Methods (Ref 3.1)**
  - **3 methods are available: standard avg weight, average weights based on survey, actual weight (Ref 3.1.1.3)**
  - **Method recommendation per aircraft type**
    - **Large Cabin Aircraft : standard avg weight (Ref 3.1.1.4)**
      - **Operator can elect to use survey weights if desired or if standard avg weights do not to fit certain routes or missions**
    - **Medium Cabin Aircraft : determine whether to treat as large or small cabin (Ref 3.1.1.5)**
      - **Medium cabin aircraft must be evaluated by loadability and loading schedule**
      - **If medium cabin aircraft meet the criteria they can adopt large cabin aircraft procedures.**

Chapter 3 – Loadability and Loading Schedule Criteria

- **Large cabin procedure determination**
  - **Loadability Criteria (Ref 3.1.1.5.3)**
    - **CG and Basic Empty Weight (BEW) is within manufacture's loading envelope**
    - **The CG of the zero fuel weight is within the manufacture’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**
  - **Loading Schedule Criteria (Ref 3.1.1.5.4)**
    - **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**

Chapter 3 – Small Cabin Aircraft Passenger Weights

- **Small aircraft Criteria (Ref 3.1.1.6)**
  - **Small aircraft operators can use 2 methods**
    - **Actual passenger and bag weights**
    - **Standard average passenger and standard average by survey based on an FAA-accepted survey if:**
      - **The aircraft was certificated under part 23 normal category, part 25 or part 29 (or is able to prove the aircraft has equivalent part 23 normal category or part 29 performance data) AND**
      - **When using the Window-Aisle-Remaining (Zone) Method, the operator applies the additional curtailment as prescribed in Appendix D, Additional Curtailment to CG Envelopes for Passenger Weight Variations in Small Cabin Aircraft.**

Chapter 3 – Standard Average Weight

- **Standard average weight (Ref 3.2.1)**
  - **Standard average weights come from CDC and National Health and Nutrition Examination Survey (NHANES). These averages do not account for clothing**
  - **If no gender is given the assumption is 50/50 male to female split**
  - **Use 5 pounds for summer clothing / 10 pounds for winter clothing.**
    - **Use winter weights from Nov 1 to April 30 / summer weights May 1 to Oct 31**
    - **Deviations from these dates need FAA approval**
  - **Standard average weights must be established by the operator and summited for review by the FAA**
    - **If accepted the standard average weights must be entered into the operator's OpSpecs, MSpecs, or LOA as applicable.**

Chapter 3 – CDC/NHANES Example

Table 2. Mean weight (pounds) among men and women aged 20 and over, by survey years, age group, and race and Hispanic origin: United States, 1999–2016

Sex, age, and race and Hispanic origin	Survey years								
	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010	2011–2012	2013–2014	2015–2016
Men	Mean (standard error)								
20 and over[1] (crude)	189.1 (1.5)	191.8 (1.1)	193.5 (1.1)	196.0 (1.7)	194.7 (1.4)	196.3 (1.4)	194.4 (1.4)	197.0 (1.2)	197.8 (1.9)
20 and over[1,2] (age adjusted)	189.4 (1.5)	191.2 (1.2)	193.3 (1.1)	195.7 (1.7)	194.6 (1.4)	196.2 (1.3)	194.3 (1.4)	197.0 (1.3)	197.9 (2.0)
Age group:									
20–39	185.8 (2.0)	188.1 (1.6)	190.4 (2.3)	192.1 (2.3)	189.9 (2.1)	193.1 (1.9)	190.7 (1.9)	194.4 (2.7)	196.9 (3.1)
40–59	194.3 (2.6)	197.7 (1.5)	198.4 (2.0)	203.0 (2.5)	199.9 (2.0)	202.0 (2.4)	200.4 (2.3)	200.7 (1.8)	200.9 (2.0)
60 and over	187.8 (1.7)	186.2 (1.5)	190.0 (1.7)	190.0 (1.4)	194.0 (1.8)	192.1 (1.5)	190.5 (2.5)	195.4 (2.7)	194.7 (1.9)
Race and Hispanic origin[2]:									
Non-Hispanic white	192.3 (1.7)	194.6 (1.3)	196.3 (1.3)	197.8 (1.6)	198.2 (1.3)	199.5 (1.4)	196.7 (1.8)	200.2 (2.0)	202.2 (2.4)
Non-Hispanic black	188.7 (1.7)	190.8 (1.9)	196.4 (3.8)	201.0 (1.9)	197.1 (2.0)	201.1 (2.4)	198.4 (2.1)	199.3 (2.6)	197.7 (2.6)
Non-Hispanic Asian	--- ---	--- ---	--- ---	--- ---	--- ---	--- ---	159.1 (1.6)	161.7 (1.4)	161.1 (1.3)
Hispanic[3]	--- ---	--- ---	--- ---	--- ---	184.1 (2.4)	187.0 (2.4)	187.2 (1.8)	189.6 (3.1)	190.5 (1.9)
Mexican-American	177.9 (1.6)	177.5 (1.7)	180.1 (2.1)	179.3 (2.0)	184.0 (2.7)	185.6 (2.8)	189.5 (2.5)	191.9 (2.3)	190.4 (2.5)
Women									
20 and over[1] (crude)	163.6 (1.7)	162.9 (1.2)	164.2 (1.6)	165.1 (1.7)	166.1 (1.3)	166.2 (0.9)	167.1 (1.3)	169.8 (1.3)	170.5 (1.7)
20 and over[1,2] (age adjusted)	163.8 (1.7)	162.8 (1.3)	164.1 (1.7)	164.8 (1.7)	166.3 (1.4)	166.1 (1.0)	167.2 (1.3)	170.1 (1.4)	170.6 (1.7)
Age group:									
20–39	161.9 (2.1)	158.9 (2.1)	160.6 (2.4)	160.5 (2.4)	166.6 (2.7)	164.3 (2.1)	165.1 (1.8)	169.4 (1.7)	167.6 (1.9)
40–59	169.4 (2.9)	168.6 (2.4)	171.0 (2.5)	172.3 (2.7)	170.2 (1.8)	167.8 (1.5)	172.3 (1.7)	175.2 (2.7)	176.4 (3.0)
60 and over	157.9 (1.3)	160.3 (1.4)	159.0 (1.3)	160.2 (1.9)	159.5 (1.1)	166.6 (1.3)	162.5 (2.3)	163.1 (1.7)	166.5 (2.6)
Race and Hispanic origin[2]:									
Non-Hispanic white	161.9 (2.2)	162.2 (1.3)	162.6 (2.0)	164.1 (1.9)	165.8 (2.2)	165.0 (1.2)	167.1 (1.9)	170.4 (1.8)	170.9 (2.1)
Non-Hispanic black	185.9 (2.3)	179.3 (1.9)	185.1 (2.3)	184.1 (2.3)	185.0 (3.0)	189.5 (1.9)	190.0 (2.2)	190.0 (1.9)	186.1 (2.4)
Non-Hispanic Asian	--- ---	--- ---	--- ---	--- ---	--- ---	--- ---	131.8 (1.7)	131.0 (1.8)	132.4 (1.1)
Hispanic[3]	--- ---	--- ---	--- ---	--- ---	160.7 (1.3)	160.1 (1.6)	162.4 (1.3)	166.3 (2.1)	169.0 (1.6)
Mexican-American	157.5 (2.2)	157.5 (2.1)	162.7 (2.7)	160.8 (2.3)	160.8 (0.9)	161.6 (1.4)	165.0 (2.4)	170.0 (2.2)	171.9 (1.5)

--- Data not available.
[1]Includes other races not shown separately.
[2]Age adjusted to the projected 2000 U.S. census population using age groups 20–39, 40–59, and 60 and over.
[3]Includes Mexican-American persons.

SOURCE: NCHS, National Health and Nutrition Examination Survey, 1999–2016.

Chapter 3 – Standard Crewmember Weights

- **Standard Crewmember Weight (Ref 3.2.2)**
  - **CAMI first and second class medical certificate weights may be used or averages developed through a survey**

Table 3-2. Standard Crewmember Weights

Crewmember	CAMI Medical Certificate Average Weights	CDC/ NHANES Average Weight	Uniform Weights	Crewmember Average Weights with Uniform	Crewmember Average Weight with Uniform & Bags
Male flightcrew member	lbs	lbs	lbs	lbs	lbs
Female flightcrew member	lbs	lbs	lbs	lbs	lbs
Flight attendant	NA	lbs	lbs	lbs	lbs
Male flight attendant	NA	lbs	lbs	lbs	lbs
Female flight attendant	NA	lbs	lbs	lbs	lbs

	Crewmember Bag Weights
Crewmember roller bag	lbs
Pilot flight bag	lbs
Flight attendant kit	lbs

Chapter 3 – Unique Passengers

- **COMAT, Freight, and Mail (Ref 3.2.3)**
  - **Use actual weights for company materials, aircraft parts, and freight**
  - **Operators should use weights provided in mail manifest**
- **Nonstandard Weight Groups (Ref 3.2.4)**
  - **Sports teams**
    - **Actual weights if no approved standard weight is available**
    - **Adjustments should be made if part of a standard passenger load**
  - **DOD charter**
    - **FAA approved averages can be used for mixed loads of military and dependants**
    - **DOD requires actuals for DOD charter missons**

Chapter 3 – Average Weights Based on Survey Results

- **Averages based on survey (Ref 3.3)**
  - **Surveys should be conducted to achieve a 95% confidence level. Min samples sizes:**

Table 3-3. Minimum Sample Sizes

Survey Subject	Minimum Sample Size	Tolerable Error
Adult (standard adult/male/female)	2,700	1%
Child	1,400	2%
Checked bags	1,400	2%
Heavy bag	1,400	2%
Planeside 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%

  - **A smaller sample size can be used if operators 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

Chapter 3 – Survey Sampling Methods and Plans

- **Random Sampling Methods (Ref 3.3.4.1)**
  - **Simple Random Selection**
  - **Systematic Random Selection**
  - **Elective Passenger Participation**
- **Developing a Survey Plan (Ref 3.3.5)**
  - **Operators must create and submit a survey plan to the FAA 30 days prior to start**
  - **Operators must complete the survey once started regardless of trends and submit final results to FAA for review and approval. Surveys should be reviewed every 36 months.**
  - **Procedures (Ref 3.3.6.1)**
    - **Surveys should be conducted at airports representing min 15% of daily departures**
    - **Surveys can be done for specific routes**
    - **Account for all carry-on bags, checked items and planeside loaded items**
    - **Record values at same precisions of the collection method**

Chapter 3 – Average Baggage Weight

- **Average Baggage Weight (Ref 3.3.9)**
  - A survey method like the passenger average survey method can be used
  - Heavy bags are considered anything over 50 pounds but less than 100 pounds
    - Heavy bags should be accounted for with actuals or with approved averages
  - Non-Luggage/Non-Standard Bag
    - Golf clubs, wheelchairs, windsurfing kits, boxed bicycles…
    - Dedicated surveys are needed for these items or actual weights
  - Planeside / Carry-On
    - Along with passenger surveys a carry on and planeside item survey should be done to establish standard averages

Chapter 3 – Actual Weight Programs

- **Actual Weights (Ref 3.4)**
  - **Passengers**
    - **Operators should weigh each passenger prior to boarding using a certified calibrated scale or ask passengers their weight while adding 10 pounds for clothing.**
  - **Personal Items / Bags**
    - **All items brought with the customer should be weighed as well. Account for all items through the passenger actual or weighed individually**

Chapter 4 – Pilot and Agent Reporting

- **Operator's Responsibilities (Ref 3.4)**

  - **Operators are required to develop reporting systems and foster a culture of safety**

Note 1: Section 121.665 states, "each certificate holder is responsible for the preparation and accuracy of a load manifest form before each takeoff." The FAA, however, encourages operators to develop a reporting system in order to account for any discrepancies or errors in documentation and to determine the cause of each discrepancy, in the interest of reducing the likelihood that load manifests contain incorrect information.

Note 2: While accountability for compliance with § 121.665 must be based on the original manifest, an operator is not barred from taking any corrective action determined by their safety management system (SMS) to have a positive impact on the safety of any continuing flight. For example, an operator may prepare a separate, amended manifest if the flightcrew might unknowingly exceed the maximum certified landing weight or other safety limitation without the amendment.

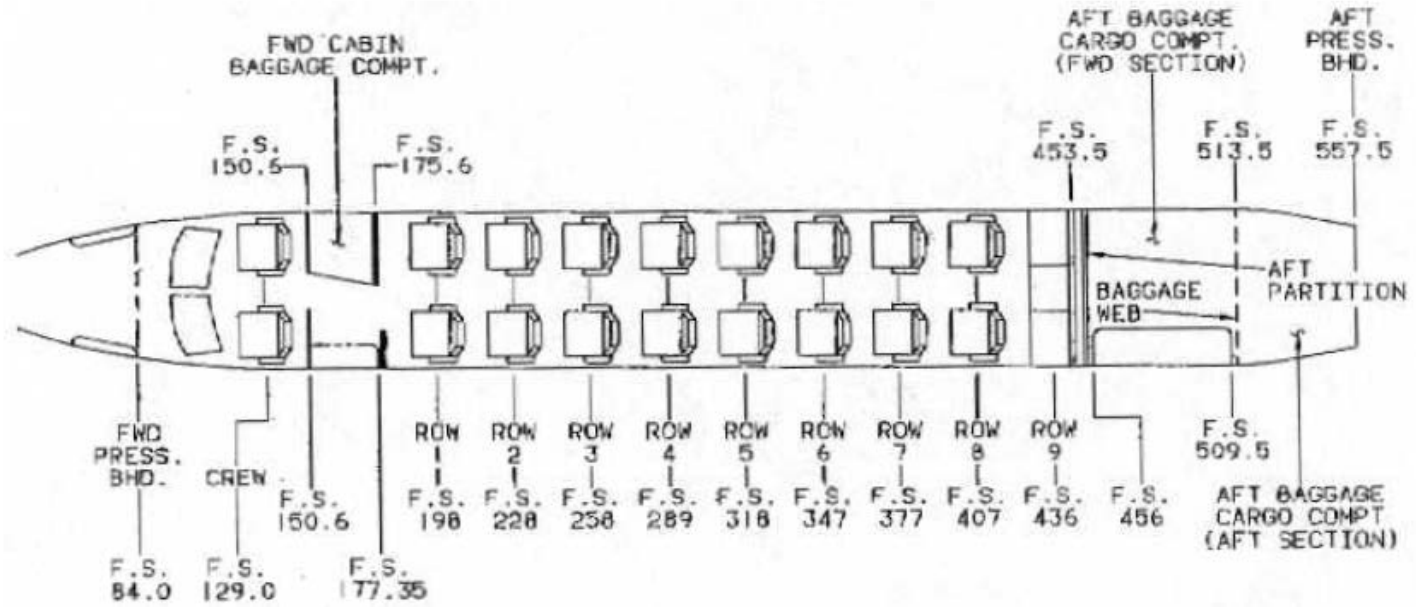
Chapter 4 – FAA Oversight

- **FAA Oversight (Ref 3.4)**
  - **W&B Control Plan approval and oversight**
    - **Responsibility falls to the operators' Principal Inspectors (PI) in Certificate Management Office (CMO) or Flight Standards District Office (FSDO)**

Appendix C – Sample Operation Loading Envelope

- **Loading Example – Assumptions (Ref C.2.1)**
  - **Certified normal aircraft 14 CFR part 23. TC of 5 or more seats.**
  - **Using standard average passenger weights of 189 lb**
  - **No-carry on baggage program**
  - **Operator survey baggage weights: 30 pounds checked and 20 pounds planeside**
  - **19 seat aircraft**

Figure C-1. Sample Aircraft Interior Seating Diagram



Appendix C - Curtailment

- **Establishment of Zones (Ref C.3.1)**
  - **Operator elects to separate the cabin by 3 zones**
  - **Determine the centroid of each zone**

Table C-1. Calculation of Zone 1 Centroid

Row No.	No. of Seats	Row Location	No. of Seats x 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 C-2. Calculation of Zone 2 Centroid

Row No.	No. of Seats	Row Location	No. of Seats x 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			

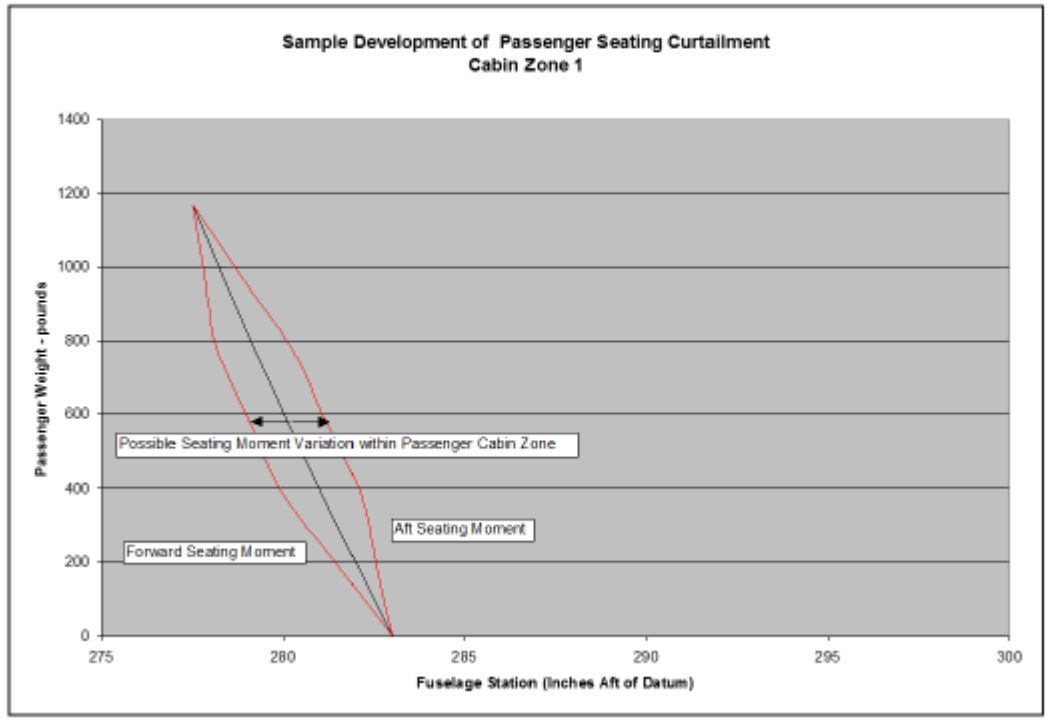
Table C-3. Calculation of Zone 3 Centroid

Row No.	No. of Seats	Row Location	No. of Seats x 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			

Appendix C - Curtailment

- **Loading Assumptions (Ref C.3.3)**
  - **Compare aircraft loading based on window-aisle-remaining assumption with passenger zone centroid loading. Zone 1**

Figure C-2. Sample Passenger Seating Moment (Zone 1)



C.3.3.1 Curtailment Calculation for Zone 1.

Table C-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 C-5. Moments Resulting From the Window-Aisle-Remaining Assumption for Zone 1

Passenger No.	Assumed Row	Assumed Weight	Assumed 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

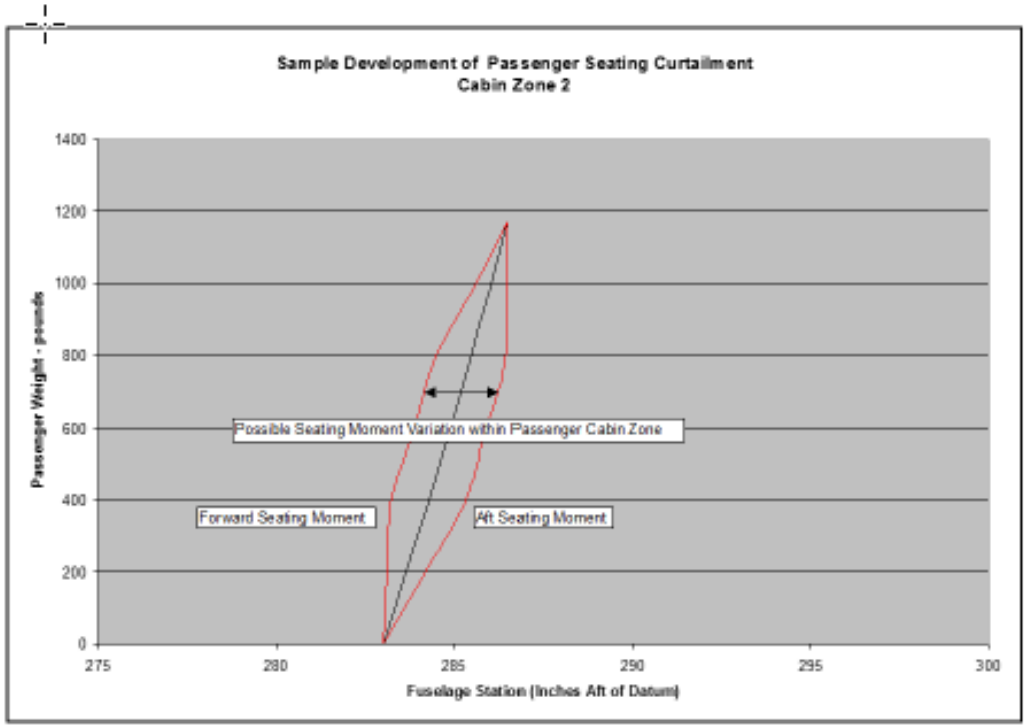
Table C-6. Comparison of Moments for Zone 1

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

Appendix C - Curtailment

- **Loading Assumptions (Ref C.3.3)**
  - **Compare aircraft loading based on window-aisle-remaining assumption with passenger zone centroid loading. Zone 2**

Figure C-3. Sample Passenger Seating Moment (Zone 2)



C.3.3.2 Curtailment Calculation for Zone 2.

Table C-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 C-8. Moments Resulting From the Window-Aisle-Remaining Assumption for Zone 2

Passenger No.	Assumed Row	Assumed Weight	Assumed 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 C-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

Appendix C - Curtailment

- **Loading Assumptions (Ref C.3.3)**
  - **Compare aircraft loading based on window-aisle-remaining assumption with passenger zone centroid loading. Zone 3**

Figure C-4. Sample Passenger Seating Moment (Zone 3)

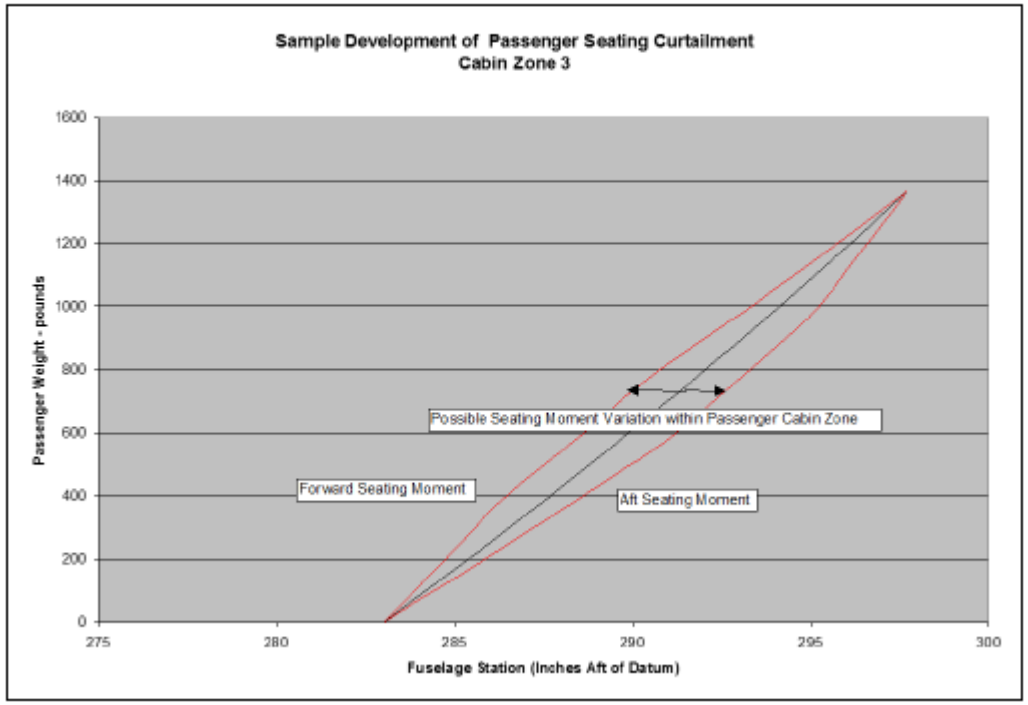


Table C-10. Moments Resulting From the Zone Centroid Assumption for Zone 3

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 C-11. Moments Resulting From the Window-Aisle-Remaining Assumption for Zone 3

Passenger No.	Assumed Row	Assumed Weight	Assumed 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 C-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

Appendix C – Adverse Loading

- **Determining Adverse Loading**
  - **Using loading scenarios calculations, determine the seating with the largest difference in moment.**
  - **Zone 1 = 11,340 / Zone 2 = 10,962 / Zone 3 = 14,364 / Total = 36,666 inch-pounds**
  - **Apply this moment Fwd and Aft to obtain the curtailment**
  - **Using actual seating location avoids the curtailment calculation**

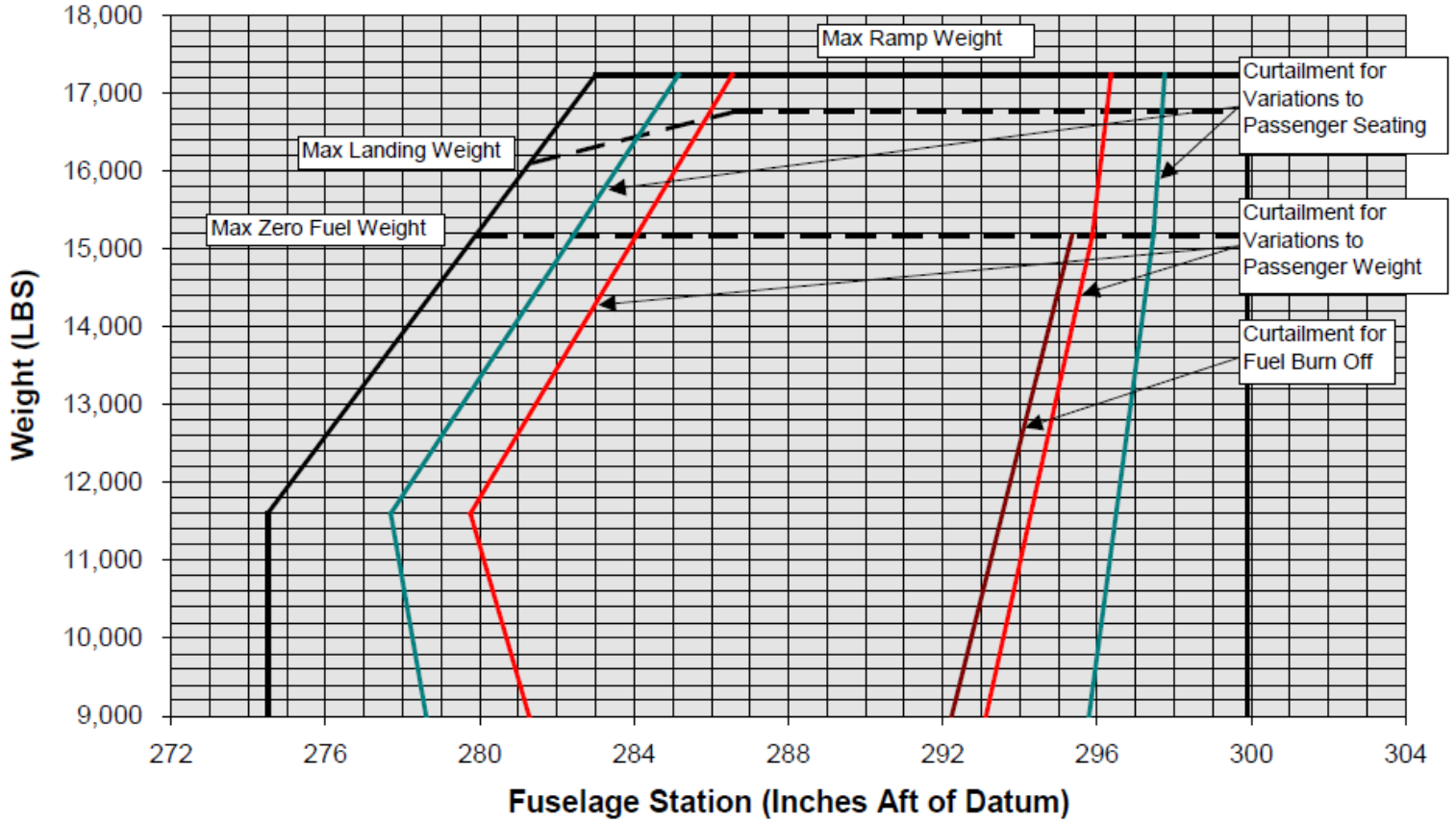
Appendix C – Additional Curtailments

- **Additional Curtailments for this Example (Ref C.4)**
  - **Variation in passenger weight – By using average weights on a small aircraft additional curtailment may be needed for passenger weight variation**
  - **Fuel density – The fuel doesn't significantly change CG, no curtailment needed**
  - **Fuel movement – Manufacturer has considered fuel movement already**
  - **Fluids – No Lav or catering**
  - **Baggage – No inflight baggage access. No curtailment needed if bags properly stowed**
  - **Passenger/Crew Movement - minimal movement expected due to no lav**
  - **Flap and Landing Gear Movement – Manufacturer considered already**
  - **Fuel Consumption**
    - **Small aft movement of fuel vectors calls for a curtailment of -8,900 inch-pounds**

Appendix C – Sample Envelope with Curtailments

- **Sample Envelope with Curtailments**

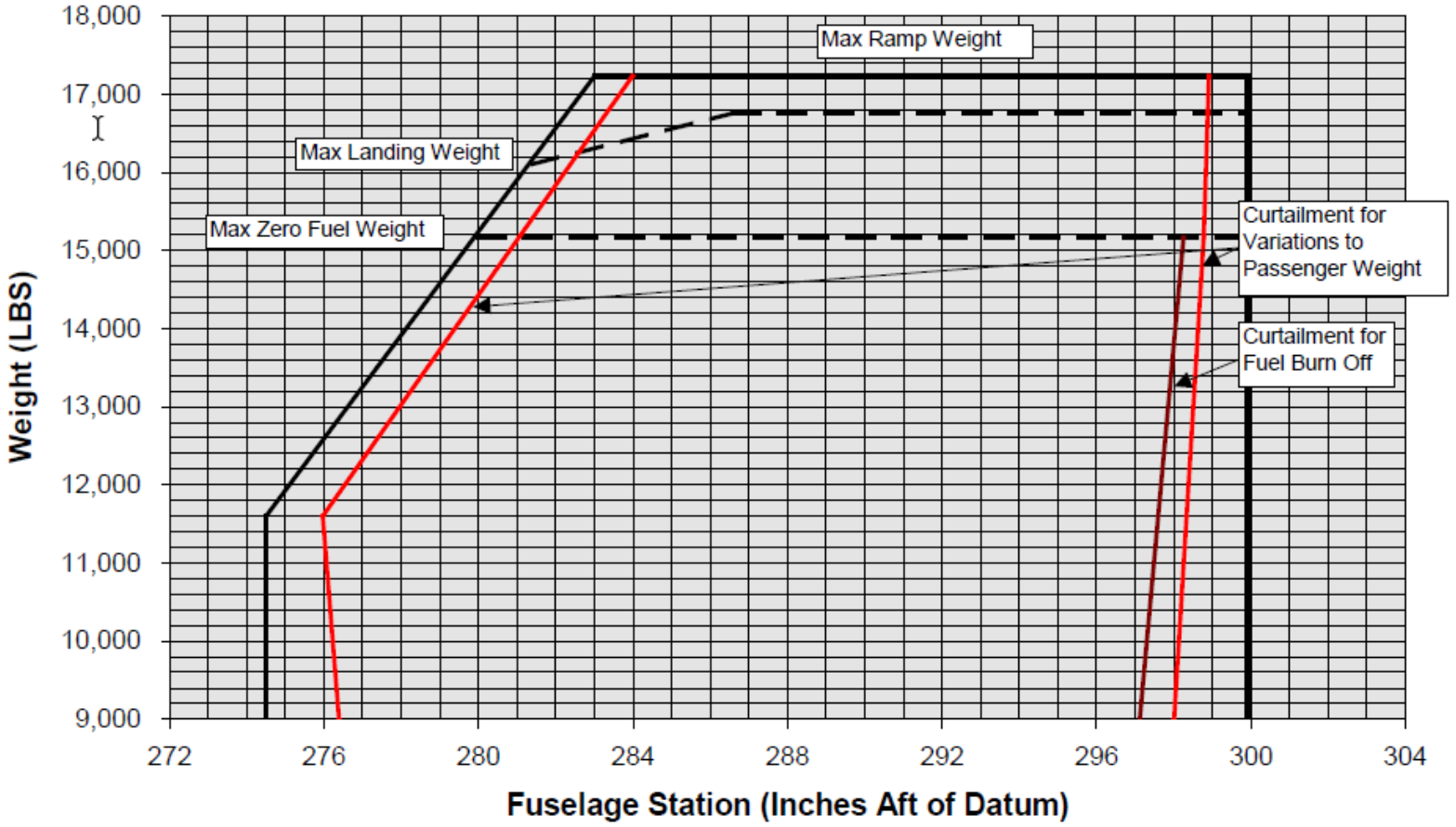
Figure C-5. Operational Loading Envelope With a Curtailment for Variations in Passenger Seating



Appendix C – Sample Envelope with Curtailments

- **Sample Envelope with Curtailments using actual passenger seating**

Figure C-6. Operational Loading Envelope Using Actual Seating Location of Passengers



Closing Remarks

- **AC-120-27F**
  - **AC-120-27F gives further clarification on aircraft operational topics while giving leeway to various W&B control methods, tools and systems**
  - **It falls to the operators to use the aircraft correctly by understanding and controlling their aircraft W&B**
  - **It is important for Mass Properties engineers to be aware of FAA guidance and operators' tasks related to the use of their aircraft**
  - **AC-120-27F has further detailed examples in Appendix D and F**

Questions?