



FAA
Aviation Safety

2011

Review of Standard Average Passenger Weight



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Flight Standards Service
Analysis and Information
AFS-20
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FINAL DRAFT

Review of Standard Average Passenger Weight

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Executive Summary

The increase in the weight of children aged 2 to 12 years warrants a revision to Advisory Circular 120-27E. The Federal Aviation Administration should amend its guidance governing the weight and balance of passenger aircraft. The average American child aged 2 to 12 years weighs significantly more than the assumed average weight per person utilized in current guidance. Updating the guidance to more accurately reflect today's average weight per person will maintain intended safety levels by taking this weight increase into account. A review of the current Advisory Circular 120-27E identifies the increase in weight of individuals in the United States is trending upwards. The guidance of Advisory Circular 120-27E states that an increase in weight of more than two percent requires a revision. The children weight has increased 6.1 percent or 4.5 pounds, and necessitates an increase to the corresponding tables. The Standard Average Passenger Weight for a child increases to 87 lbs (summer) and 92 lbs (winter). The data utilized in the current version was obtained more than ten years ago. The criticality of the weight and balance program with respect to the safety of flight warrants that Advisory Circular 120-27E be reviewed on a biannual basis to coincide with the release of the National Health and Nutrition Examination Survey data from the Centers for Disease Control and Prevention.

Problem Statement

The weight of the United States population has grown significantly since 1960. The figures released by the Centers for Disease Control and Prevention (CDC) show that the average weight for men aged 20-74 years rose from 166.3 pounds in 1960 to 191 pounds in 2002, while the average weight for women the same age increased from 140.2 pounds in 1960 to 164.3 pounds in 2002. This is a striking 25 pound difference for the male population.

Background

The CDC information has been utilized to create weight standards across industry. In the aviation industry, Federal Aviation Administration (FAA) AC 120-27E (Advisory Circular 120-27E) provides weight and balance data. Table 2-1 in AC 120-27E states that the average passenger weight is 190 pounds (summer [May 1 to October 31]), and 195 pounds (winter [November 1 to April 30]). This average is calculated through averaging a 200 pound male (summer), and a 179 pound female (summer), as well as a 205 pound male (winter), and a 184 pound female (winter). These figures assume a 21 pound allowance for carry-on items.

These figures for weight averages are not consistent with the National Health Statistics Report dated October 2, 2008. The report lists the male, age 20 and over, average as 194.7 pounds and the female, age 20 and over, average as 164.7 pounds. These weights were provided in a clinical setting with the subject population wearing only socks, undergarments, and hospital gown.

In a period of six years there had been a continued increase in the weight of the population. Some information is collected in more than one survey and estimates of the

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same statistic may vary among surveys because of different survey methodologies, sampling frames, questionnaires, definitions, and tabulation categories. The statistics gathered for AC 120-27E are from the NHANES (National Health and Nutrition Examination Survey) 1999-2000 report.

The CDC reports that “obesity is common, serious, and costly. In 2009, about 2.4 million more adults were obese than in 2007.” There is however a distinction between the overweight and obese individual and the weight standards of a passenger. Unless an overweight/obese individual exceeds the FAA standard average passenger weight, that individual is not a factor in calculations.

The perception of overweight/obese individuals providing an increase to weight figures, and the implementation of revised weight standards in other transportation sectors has prompted Flight Standards to exam the current weight standards provided through AC 120-27E.

Methodology

The methodology, employed in the manner given, was dictated in AC 120-27E. The 1999-2000 NHANES data set was utilized to re-verify the computations used to generate the figures in AC 120-27E.

The methodology for this analysis introduced weighted calculations as a mean for determining means and standard deviation. This form of calculation was chosen in lieu of the inability to find the method utilized in the current AC 120-27E calculations. The weighted figures provide a truer representation of the study population when compared to a straight average calculation.

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Data sets were obtained from the NHANES 2007-2008 Demographics File, and the NHANES 2007-2008 Examination File. The records in each data set were matched using the variable “SEQN” in each data set. The weight and age data were extracted from each SEQN and analyzed. The analysis of the data was in accordance with the methodology of AC 120-27E. The analysis was conducted on the overall population, and segments of the population with respect to age and gender. Calculations were compiled and reviewed on children aged 2 through 12, and on male and female individuals over the age of 12.

1999-2000 NHANES Data

The 1999-2000 NHANES data provides a total sample population of 9,965 subjects. Only 9,197 subjects provided weight data. The remaining 768 subjects with no weight data were removed from the data set. 692 subjects ages 0 – 1 were removed from the data set. The remaining data set of 8,505 subjects was divided into two sets; subjects aged 2 through 12, and aged 13 and over. The age 2 – 12 data set provided 2,138 subjects. The age 13 and over data set provided 6,367 subjects.

AC 120-27E states that the standard deviation of the sample set was 47 pounds. This can not be duplicated with various configurations of the data set.

The standard deviations were calculated for the various populations as provided in Tables 1 through 4.

Table 1

Total Weight Subjects

Descriptive Statistics	N	Standard Deviation
	9197	65.91

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Table 2

Population of Interest

Descriptive Statistics	N	Standard Deviation
	8505	59.90

Table 3

Age 2 to 12

Descriptive Statistics	N	Standard Deviation
	2138	35.46

Table 4

Ages 13 and Over

Descriptive Statistics	N	Standard Deviation
	6367	44.27

The FAA does not specify in AC 120-27E the type of analysis process utilized to calculate the standard average passenger weights. Appendix 2 (1.c.) of AC 120-27E provides a simplistic methodology in determining the weights. The simplistic analysis tools available in IBM's SPSS Statistics 19.0 software are utilized in this report. There are more complex tools available in SPSS, but they are not afforded to the analyst in the current version. Calculations outside of SPSS were accomplished by creating the formulas and inserting them into Microsoft Excel.

Using the "simplistic" FAA version of conducting the Standard Average Passenger Weight (SAPW) analysis, the computed weights for the 1999-2000 NHANES data set provides a different set of computations as listed in AC 120-27E, and shown in Table 5.

Table 5

1999-2000 Child Mean

Descriptive Statistics	N	Mean
		LB
	2138	68.05

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This mean plus the additional 21 pound allowance (summer) equates to 89 pounds (rounded). The 89 pound calculation exceeds the computation provided in AC 120-27E of 82 pounds. The average weight of a child based on AC 120-27E without baggage or clothing, such as in a clinical setting would be 61 pounds.

Before accounting for standard deviation, the age 13 and over mean equates to 165.99 illustrated in Table 6.

Table 6

<i>1999-2000 Age 13 and Over Mean</i>		
<u>Descriptive Statistics</u>	<u>N</u>	<u>Mean</u>
		<u>LB</u>
	6367	165.99

Computing the SAPW using the standard deviation of 47 pounds provided in AC 120-27E and multiplying it by 2 equates to 94 pounds. These figures provide a calculated mean of 161.36 shown in Table 7.

Table 7

<i>Mean at 47 Pound Standard Deviation</i>		
<u>Descriptive Statistics</u>	<u>N</u>	<u>Mean</u>
		<u>LB</u>
	6126	161.36

Computing the SAPW using the standard deviation of 44.27 pounds provided in this report and multiplying it by 2 equates to 88.54 pounds. These figures provide a calculated mean of 160.77 provided in Table 8.

Table 8

<i>Mean at 44.27 Pound Standard Deviation</i>		
<u>Descriptive Statistics</u>	<u>N</u>	<u>Mean</u>
		<u>LB</u>
	6079	160.77

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The addition of 21 pounds (summer) to the two computations finds that the SAPW in the AC 120-27E method is 182.36, and the non-AC method provided a computation of 181.77. These two figures rounded equate to 182 pounds for the SAPW (summer).

AC 120-27E states that the SAPW (summer) should be 190 pounds. In the winter months, 5 additional pounds are added to the summer weights.

AC 120-27E indicates that from this remaining data set, the male and female average weights were calculated. Tables 9 and 10 provide the means for male and female subjects.

Table 9

<i>Male Mean at 44.27 Pound Standard Deviation</i>		
Descriptive Statistics	N	Mean
		LB
	2867	169.24

Table 10

<i>Female Mean at 44.27 Pound Standard Deviation</i>		
Descriptive Statistics	N	Mean
		LB
	3212	153.21

The addition of 21 pounds (summer) to these figures provides that the male weight is 190 pounds, and the female weight is 174 pounds.

Using a weighted population method

The arithmetic mean is not the same as the weighted mean. The arithmetic simply adds all the numbers in a column together and divides by the number count. This method is generally referred to as the average. The weighted mean however provides a weighted value to each of the numbers in a column. In this instance the population will have

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subjects that have subjects of a particular weight. There will be more subjects at one particular weight than there are subjects at another particular weight. The weighted mean takes this into account mathematically.

Weighted Mean

=SUMPRODUCT(C2F:C2L,C1F:C1L)/SUM(C1F:C1L)

Weighted Variance

=SUMPRODUCT((C2F:C2L -SUMPRODUCT(C2F:C2L,C1F:C1L)/SUM(C1F:C1L))^2,C1F:C1L)

Weighted Standard Deviation

=SQRT(SUMPRODUCT((C2F:C2L -SUMPRODUCT(C2F:C2L,C1F:C1L)/SUM(C1F:C1L))^2,C1F:C1L)/(SUM(C1F:C1L)-1))

Utilizing data from the 1999-2000 NHANES

The weighted mean for the population study is 172.34.

The weighted standard deviation for the population is 45.44.

The weighted mean for the population study after the removal of all points more than two standard deviations above and below the weighted mean indicates a new mean of 167.21

Utilizing data from the 2007-2008 NHANES

The weighted mean for the population study is 176.15.

The weighted standard deviation for the population is 47.01.

The weighted mean for the population study after the removal of all points more than two standard deviations above and below the weighted mean indicates a new mean of 171.01.

2007-2008 NHANES Data

The 2007-2008 data set consisted of 10,149 subjects. From this set, 2,590 were deleted due to lack of weight information. From the remaining subjects, 745 subjects

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aged 0 to 1 were removed. The data was further divided into two sets; one set for ages 2 to 12, and the remaining ages 13 and over. The subjects aged 13 and over were again split into male and female groups.

The age 13 and up subjects were computed as to the Arithmetic Mean, the Weighted Mean (WTINT2YR), and the Weighted Mean (WTMEC2YR). The standard deviation was computed for STDEV, STDEV A, STDEV P, STDEV PA, the weighted STDEV WTINT2YR, and weighted STDEV WTMEC2YR. It is noted that STDEV and STDEV A, and, STDEV P and STDEV PA provided the same values, and are further addressed solely as STDEV and STDEV P. Each of these were multiplied by two in order to provide two standard deviations.

A minimum and a maximum value were calculated for the Arithmetic Mean, the Weighted Mean (WTINT2YR), and the Weighted Mean (WTMEC2YR) by subtracting the standard deviation from the mean for the minimum, and adding the standard deviation and the mean for the maximum.

The minimum and maximum standard deviations were utilized as a cutoff point for the weight figures. Those figures below the minimum were eliminated, and those above the maximum were removed. The remaining groups of numbers were used to calculate the matrix of weights.

Results

Tables 11, 12, and 13 provide a matrix for the various computations that may be derived from three types of means, and four types of standard deviation.

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Table 11

Adult

Source	Arithmetic Mean	Weighted Mean (WTINT2YR)	Weighted Mean (WTMEC2YR)
	LB	LB	LB
STDEV	168.81	170.99	170.97
STDEV P	168.81	170.99	170.97
STDEV WTINT2YR	168.83	171.01	170.99
STDEV WTMEC2YR	168.83	171.01	170.99

Table 12

Males

Source	Arithmetic Mean	Weighted Mean (WTINT2YR)	Weighted Mean (WTMEC2YR)
	LB	LB	LB
STDEV	179.32	183.65	183.65
STDEV P	179.32	183.65	183.65
STDEV WTINT2YR	179.38	183.65	183.83
STDEV WTMEC2YR	179.38	183.65	183.99

Table 13

Females

Source	Arithmetic Mean	Weighted Mean (WTINT2YR)	Weighted Mean (WTMEC2YR)
	LB	LB	LB
STDEV	158.84	159.37	159.37
STDEV P	158.84	159.37	159.37
STDEV WTINT2YR	158.84	159.42	159.42
STDEV WTMEC2YR	158.84	159.42	159.42

Table 14 provides the mean weights for children. There is no adjustment for standard deviation.

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Table 14

<i>Child (Age 2 to 12)</i>	
Source	LB
Arithmetic Mean	64.65
Weighted Mean (WTINT2YR)	66.01
Weighted Mean (WTMEC2YR)	65.88

Table 15 provides a weighted mean of the means. These computations are the resultant of calculating the weighted means of those found in Tables 11, 12, 13, and 14.

Table 15

<i>Weighted Mean of Means</i>		
Source	Plus Carry-On	
	LB	LB
Adult	170.27	191.27
Males	182.26	203.26
Females	159.20	180.20
Child (Age 2 to 12)	65.51	86.51

Tables 16 and 17 provide the weight as the weighted mean of the means plus an additional 21 pounds for carry-on baggage. This figure is compared to the figure provided for in AC 120-27E, and the resulting difference is given.

Table 16

<i>Summer Weights</i>				
Source	Plus Carry-On		Current AC 120-27E Figure	Difference
	LB	LB		
Adult	170.27	191.27	190	1.27
Males	182.26	203.26	200	3.26
Females	159.20	180.20	179	1.20
Child (Age 2 to 12)	65.51	86.51	82	4.51

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Table 17

Winter Weights

Source	Plus Carry-On	Current AC 120-27E Figure	Difference
	LB	LB	LB
Adult	170.27	196.27	1.27
Males	182.26	208.26	3.26
Females	159.20	185.20	1.20
Child (Age 2 to 12)	65.51	91.51	4.51

Table 18 and 19 compare the difference to a maximum value that can not be exceeded without requiring a change to the figure provided in Table 2-1 of AC 120-27E. The maximum exceed value is that calculated as two percent of weight per passenger provided in Table 2-1 of AC 120-27E.

Table 18

Summer Weights

Source	Difference	Maximum Exceed Value	Requires Table 2-1 Change
	LB	LB	
Adult	1.27	3.80	No
Males	3.26	4.00	No
Females	1.20	3.58	No
Child (Age 2 to 12)	4.51	1.64	Yes

Table 19

Winter Weights

Source	Difference	Maximum Exceed Value	Requires Table 2-1 Change
Adult	1.27	3.90	No
Males	3.26	4.10	No
Females	1.20	3.68	No
Child (Age 2 to 12)	4.51	1.74	Yes

Table 20 depicts the proposal for the changed Table 2-1 of AC 120-27E.

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Table 20

Proposed Table 2-1 Change

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)	87 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)	92 lb

Discussion

The standard average passenger weights provided in AC 120-27E Tables 2-1 and 2-2 were established based on data from U.S. Government health agency surveys. The standard average passenger weights in AC 120-27E Tables 2-1 and 2-2 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.

The United States Coast Guard has released a discussion in the Federal Register (Vol. 76, No. 67) in which they address the increase weight of the average. The increase in weight has prompted the Coast Guard to initiate a total revamping of the boating industry to recalculate all of their data. The Coast Guard has been using a figure of 140 lbs as the Assumed Average Weight Per Person (AAWPP) since 1960 and has determined that the AAWPP revised figure is 185 lbs.

The Department of Transportation, Federal Transit Administration (FTA) has

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addressed the increases of weight in the U.S. population. The bus industry has been utilizing figures that understate the weights of individuals as well as the girth of individuals. The Federal Register (Vol. 76, No. 49) indicates that the current figure of 150 lbs was instituted in 1971. The current revision is based upon the figures derived from the Anthropometric Reference Data for Children and Adults: United States, 2003-2006 provided in the NHANES from the CDC. This data comes from one of the same source utilized by the FAA. The FTA has proposed that the weight used be increased to 175 lbs, as well as increasing the free floor space of a standing passenger from 1.5 square feet to 1.75 square feet to accommodate the increase in passenger girth.

The United States Air Force provides guidance in Technical Order AFI11-2C-5V3ADD-A which places an allowance for passengers at 175 lbs each, plus 70 lbs for each piece of passenger baggage.

AC 120-27E addresses the computations used to create the Standard Average Passenger Weight. AC 120-27E states that the subjects weights were computed allowing for a reduction in clothing. This is in concurrence to the NHANES report which indicates that all the subjects were weighed in hospital gowns and socks. This weight of hospital attire would be minimal, as compared to a fully clothed individual. The FAA currently makes weight allowances for clothing of 5 pounds in the summer, and 10 pounds in the winter.

Conclusion

A compilation of data from various NHANES sources was utilized to determine the Standard Average Passenger Weights per AC 120-27E. The analysis concluded that the data from the 2007-2008 NHANES data provided the same average adult weight of

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190 lbs (summer) and 195 lbs (winter) as found using the same computational method found in the AC 120-27E.

AC 120-27E dictates that “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 weight.”

There is no difference in the adult Standard Average Passenger Weight; however, there is a significant change in the child weight. The current child weight listed in AC 120-27E Table 2-1 is 82 lbs (summer) and 87 lbs (winter). Based upon the data provided in the 2007-2008 NHANES, the Standard Average Passenger Weight for a child increases to 87 lbs (summer) and 92 lbs (winter). This is an increase of 6.1 percent from the 1999-2000 NHANES data set used for AC 120-27E.

Recommendations

The increase in the child weight (2 years to less than 13 years) warrants a revision to Table 2-1 Standard Average Passenger Weights, and Table 2-2 Average Passenger Weights for Operators with a No-Carry-On Bag Program. The revised tables would become thus:

TABLE 2-1. STANDARD AVERAGE PASSENGER WEIGHTS

Standard Average Passenger Weight	Weight Per Passenger
Summer Weights	
Average adult passenger weight	190 lbs
Average adult male passenger weight	200 lbs
Average adult female passenger weight	179 lbs
Child weight (2 years to less than 13 years)	87 lbs
Winter Weights	
Average adult passenger weight	195 lbs
Average adult male passenger weight	205 lbs
Average adult female passenger weight	184 lbs
Child weight (2 years to less than 13 years)	92 lbs

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

Standard Average Passenger Weight	Weight Per Passenger
Summer Weights	
Average adult passenger weight	184 lbs
Average adult male passenger weight	194 lbs
Average adult female passenger weight	173 lbs
Child weight (2 years to less than 13 years)	81 lbs
Winter Weights	
Average adult passenger weight	189 lbs
Average adult male passenger weight	199 lbs
Average adult female passenger weight	178 lbs
Child weight (2 years to less than 13 years)	86 lbs

The Federal Aviation Administration should amend its guidance governing the weight and balance of passenger aircraft. The average American child aged 2 to 12 weighs significantly more than the assumed average weight per person utilized in current guidance. Updating the guidance to more accurately reflect today’s average weight per person will maintain intended safety levels by taking this weight increase into account. It is recommended that the weights used for AC 120-27E be reviewed on a biannual basis that coincides with the release of the NHANES data from the CDC.

Paragraph 211 of AC 120-27E requires that the standard deviation formula be corrected to include the numerator and denominator under the square root sign as a singular equation instead of as depicted with the square root computed separately for the numerator and denominator.

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References

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- Passenger Weight and Inspected Vessel Stability Requirements. (2011). 76 Fed. Reg. 19275.

Appendices

Review of Standard Average Passenger Weight

Appendix A

[Federal Register](#)

[April 7, 2011](#)

[Passenger Weight and Inspected](#)

[Vessel Stability Requirements](#)

Appendix B

[Federal Register](#)

[March 14, 2011](#)

[Bus Testing: Calculations of Average](#)

[Passenger Weight and Test Vehicle Weight](#)

Appendix C

United States Air Force

Technical Order AF11-2C-5V3ADD-A

Table 4.1

Standard Weight Information

Appendix D

[Federal Aviation Administration](#)

[Advisory Circular 120-27E](#)

Flight Standards Service
Analysis and Information
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