CABIN LINEAR LOAD

14 APR 2021

ABSTRACT

The cabin linear load limit is the maximum weight acceptable over a given length in the cabin in the longitudinal direction. The cabin linear load depends on the number and weight of the of seats, passengers, and any baggage carried on the cabin floor. This document contains guidance for determining the passenger, baggage and seat weights and best practices for use in the calculation of cabin linear load.

AUTHORS

George Nunez, Principal Engineer, Flight Operations Engineering, United Airlines
Kristine Henning, Senior Principal Engineer, Performance Engineering, Delta Air Lines
Charles Ostick, Senior Flight Operations Engineer, Alaska Airlines
Bill Yingling, Senior Engineer, Operations, Jet Blue
Brian Gleason, Chief Engineer, Operations Engineering, Southwest Airlines
Bob McCullough, Senior Engineer, Operations Engineering, American Airlines
Carlos Fonseca De Godoi, Aircraft Performance Engineer, Operational Integrity and Safety, Air New Zealand
Gail Zittel, Senior Engineer, Weight and Balance, The Boeing Company
Vincent Bouscary, Product Manager, Weight and Balance, Airbus SAS
Manual Manata, Manager, Flight Physics and Technical, Airbus Canada

REVIEW COMMITTEE

Mike Byham, Director, Operations Engineering, American Airlines
James Brenson, Manager, Performance Engineering, Spirit Airlines
Cary Robins, President, American Aeronautics
Craig Nordstrom, SAPOE

PROBLEM STATEMENT

An operator must comply with the limitations in the Weight and Balance Manual (WBM) using the weights approved in their Weight and Balance Program and Operations Specification (OpSpec) A099. One such limitation contained in the WBM is the cabin linear load, which is typically set by the strength of floor beams, floor stanchions/posts, floor panels, roller trays, shear ties, and seat tracks. Cabin linear load is shown in the WBM in pounds per inch or kilograms per meter.

While this limitation is outlined in the WBM with a high-level definition of what must be considered, there is no complete set of guidance for an operator to use when calculating cabin linear load for an aircraft/seating configuration.

This document is intended to provide that guidance. This document is intended to provide guidance for narrowbody aircraft. It will be updated at a later date to address the nuances of widebody aircraft.

CALCULATION

Cabin linear load should be calculated using the following high-level equation, while considering the methods for determining passenger, baggage, and seat weight, as well as best practices for less straight forward situations that arise based on the defined LOPA.

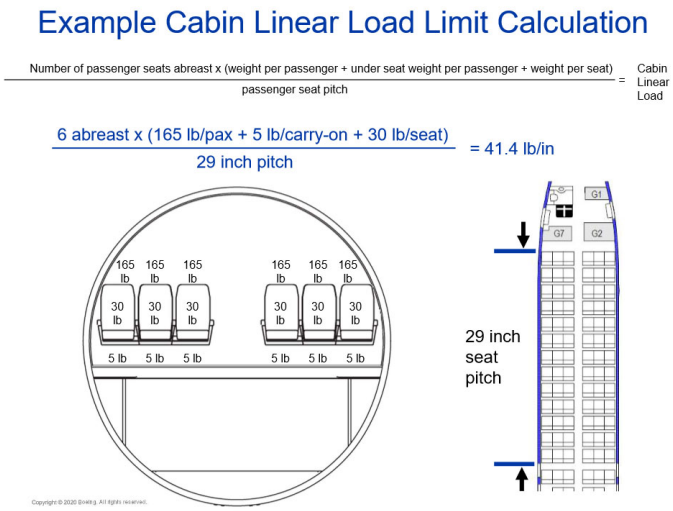
Cabin Linear Load = ((NP*WP)+(WS)+(NC*WC))/DR

Based on the following definitions:

NP = Number of Passengers seated in each row
WP = Weight of each passenger (body plus clothing) in the seats
WS = Weight of all seats (including weight of items attached or stowed in seat pocket) in each row
NC = Number of Carry-on items stowed under the seats in each row
WC = weight of each carry-on item stowed under the seats
DR = Distance on the floor occupied by each seat row

Seat pitch is often used for DR, but see DISCUSSION for other considerations.

Equivalent rearrangements of this formula are allowed, as demonstrated in the following example where WS is known for each seat position (30 lb/seat), rather than as a total weight for the seat row (180 lb), and NP and NC are the same.



WEIGHTS

The following methods outline how to determine the passenger, baggage, and seat weight to be used in the cabin linear load calculation.

Method to determine the weight of the passenger:

The weight of the passenger should be consistent with the weights used in an operator's Approved Weight and Balance program.

Method to determine the weight stowed under the seat:

Step 1: Determine the average weight of the personal item

If the personal item average weight is determined via survey, use this weight.

If this weight is not determined via survey, a percentage of the total carry-on weight may be used as the average personal item weight. When a personal item and carry-on item are allowed, the percentage or weight for the lighter item will not exceed 50%. When other considerations affect what passengers carry on the aircraft, then a smaller percentage may apply.

Step 2: Determine the number of personal items placed under the passenger seats

If the number of passengers with personal items is determined via survey, use this value.

If this number is not determined via survey, assume that 50% of the passengers place a personal item underneath the seat. For takeoff and landing a personal item can only be safely stowed under a seat or in an overhead compartment. If there is equal opportunity for passengers to choose either location, then 50% is a reasonable assumption for items stowed on the floor under a seat, versus in an overhead compartment. When other considerations affect what passengers carry on the aircraft, then a different percentage may apply.

The weight and number of personal items used in the linear load calculation should be consistent with the values in an operator's Approved Weight and Balance program.

Method to determine the weight of the seat:

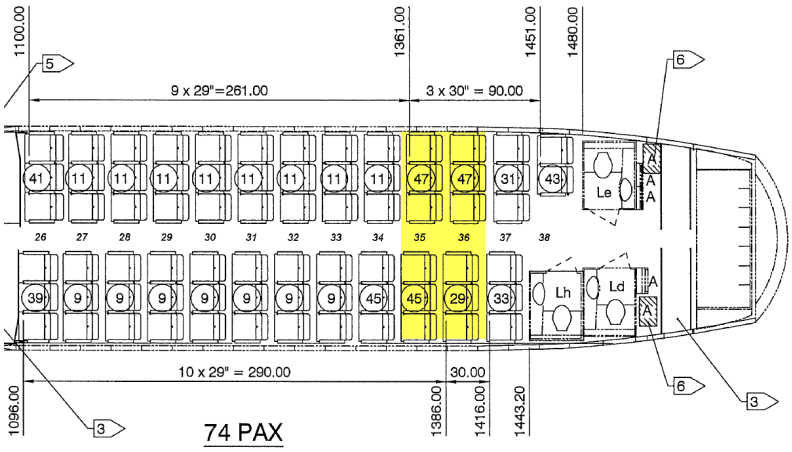
The seat weight can be found in the WBM Chapter 2 document for newly delivered aircraft and in the seat drawings or in the CMM (Component Maintenance Manual) for modified aircraft. This weight must include the weight of the IFE included in the seat, the life vest, and any items carried in the seat pocket. This is sometimes cataloged as Integrated Seat Weight (ISW).

DISCUSSION

Due to the complexity of some interior seating configurations, the following best practices are included to provide the operator with guidance for determining the cabin linear load. These include what to do when the seat rows are offset, what to do when a lavatory or galley is positioned across from a row of seats, what space in the cabin can be used for the linear load calculation, and when it might be appropriate to group together several seat rows for the calculation.

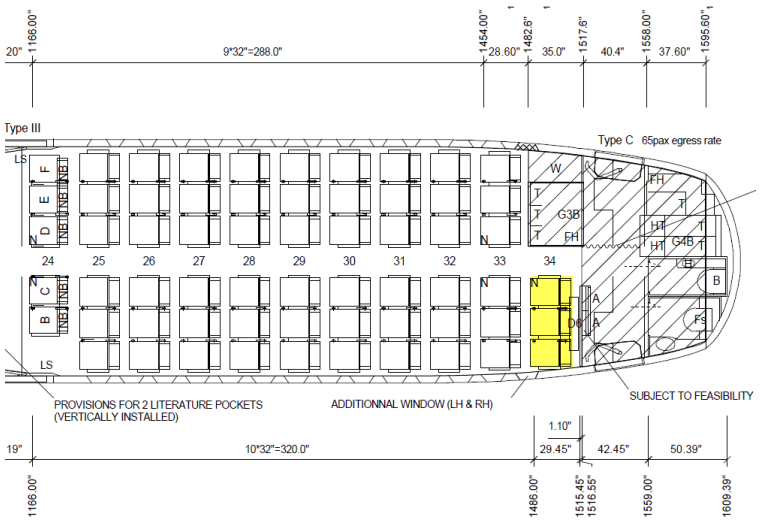
For the following items, any combination of methodologies is acceptable as long as no floor space is used twice.

1. If the seat rows are offset, the seat pitch for analysis of non-symmetrical cabins can be determined using an average seat pitch for each row where the value differs from aircraft left to right. In the following example, assuming seat pitches of 29” and 30” where indicated, it is acceptable to use DR = 29.5 in for Row 35.

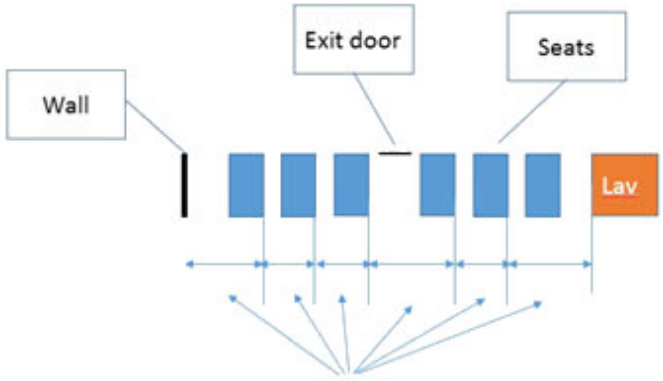


2. If the seat rows are offset, it is also acceptable to divide the cabin longitudinally and complete the cabin linear load analysis for the left and right side of the cabin separately. Each side of the cabin should comply with half the stated maximum linear load.

3. For non-symmetrical cabins where there is aircraft structure on one side of the aircraft (lavatory, galleys) and seats on the other, the aircraft structure should not be considered in the cabin linear load analysis. Rather it is sufficient to assume that the maximum available running load for this section is proportional to the amount of floor containing seats. In the example below, the maximum cabin limit is 43 lb/in. Since row 34 only has seats occupying 50% of the floor at this point, it is required to use a maximum of 21.5 lb/in for the analysis of this single triple seat.



4. Seat pitch methodology is not rigid for this analysis. Generally, seat pitch is determined using distance from the forward seat pin location to the forward seat pin location of the following row. However, other methodologies can be used to define seat pitch ***if it does not double-count any space in the cabin***. A methodology that uses all available floor space is acceptable. For example, the following image depicts acceptable seat pitches using all available floor space from the wall to the forward face of the aft lavatory.



Acceptable distances for DR in calculation.

5. When exceedances exist at the row level of the linear load calculation, removing the weight of a whole passenger from every row with an exceedance may have a much larger impact than necessary. The number of seats blocked may be reduced by locally averaging weight over consecutive rows with similar pitch. This allows a more granular control of total weight in each group of rows. Some manufacturers allow a larger number of rows to be grouped, while others restrict the number of rows over which this method can be applied. Consult with each aircraft manufacturer for specific guidance.

SUMMARY

The cabin linear load limitation is provided to the operator in the Weight and Balance Manual (WBM) and compliance must be completed using the weights approved in their Weight and Balance Program and Operations Specification (OpSpec) A099. This document provides methods and best practices to aid operators in making this calculation.