ABS/BPPP Guide to Initial Pilot Checkout:
Using Beech Weight and Balance Tables

Beech Pilot's Operating Handbook (POH) weight and balance tables may appear complex, but they are easy to use. The trick is to look at each chart in turn, gradually adding information as your loading calculation progresses. This Appendix will use sample loading data from one model of Beech Bonanza, the F33A. Use airplane-specific data and modify the technique described as needed for other airplanes.

1. Loading Form

WEIGHT AND BALANCE LOADING FORM

BONANZA ____________ DATE ____________
SERIAL NO. ____________ REG NO. ____________

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION		
2. FRONT SEAT OCCUPANTS		
3. 3rd and 4th SEAT OCCUPANTS		
4. 5th SEAT OCCUPANT		
5. BAGGAGE		
6. CARGO		
7. SUB TOTAL ZERO FUEL CONDITION		
8. FUEL LOADING		
9. SUB TOTAL RAMP CONDITION		
10. *LESS FUEL FOR START, TAXI, AND RUN UP		
11. SUB TOTAL TAKE-OFF CONDITION		
12. LESS FUEL TO DESTINATION		
13. LANDING CONDITION		

*Fuel for start, taxi, and run up is normally 12 lbs at an average mom/100 of 9.

The POH contains a Loading Form to help simplify your weight and balance calculation (left). The first step of your weight and balance calculation is to enter the airplane's basic empty weight and moment on the form. In our example, the airplane's empty weight is 2372 lbs and its moment is 194500. Note all calculations in the Beech POH divide moments by 100, so the empty moment for calculation purposes is 1945.
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(left) Fig. 1: POH loading form, IO-520 F33A

(below): Fig. 2: Empty condition data

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION	2372	1945

2. Front seat occupants

Next you'll enter weights and moments for each airplane occupant. The loading form provides one block each for front seat, $3^{rd}/4^{th}$ seat and optional 5^{th} seat occupants.

The front seats have a range of travel fore and aft, the position of which affects the moment of the seated occupant. If the seat is somewhere between fully forward and fully aft, multiply the weight of the occupant by the arm of the location--the arm is the distance, in inches, aft of the airplane's datum, and weight multiplied by arm equals the moment. Remember to divide moments by 100 if you derive the figure mathematically.

USEFUL LOAD WEIGHTS AND MOMENTS

WEIGHT	OCCUPANTS					
	FRONT SEATS		3RD & 4TH SEATS		5TH SEAT	
	FWD. POSITION ARM 85	AFT POSITION ARM 89	FWD. POSITION ARM 121	AFT POSITION ARM 127	ARM 154	
	MOMENT/100				WEIGHT	MOM/100
120	102	107	145	152	20	31
130	110	116	157	165	40	62
140	119	125	169	178	60	92
150	128	134	182	190	80	123
160	136	142	194	203	100	154
170	144	151	206	216	120	185
180	153	160	218	229	140	216
190	162	169	230	241	160	246
200	170	178	242	254	170	262

NOTE: Occupant Positions for Adjustable Seats are shown at their extreme positions. Intermediate Positions will require interpolation of the Moment/100 Values.

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Fig. 3: Aircraft occupants

For example, let's say the pilot weighs 210 pounds and flies with the seat roughly halfway between full forward and full aft, and the front-seat passenger weighs 120 pounds and rides with the seat full aft for maximum legroom. In the case:

- Moment for the pilot is derived mathematically: (210 lbs X an arm of 87)/100 = 183.
- Moment for the passenger can be found directly on the table = 107.
- Total front seat occupant weight, then is 330 lbs, and the moment is 290. Enter these numbers on the loading form (see figure 4).

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION	2372	1945
2. FRONT SEAT OCCUPANTS	330	290

Fig. 4: Including front seat occupant data

3. Rear seat occupants

Use the seating weights and moments table exactly the same way to find the moments for rear-seat occupants. Let's say in our example the combined weight of occupants of seats 3 and 4 is 280 pounds, and both passengers ride with their seat all the way back for maximum legroom. You can find the moment individually for each passenger and add them together; you can find the moment for 140 lbs on the table and double it to account for double the weight (280 lbs), or you can multiply 280 lbs by the arm of 127 for the aft-most seat position and divide the result by 100 (see figure 3). Any of these methods derive a moment of 356.

For purposes of our illustration let's assume the optional 5th seat is not installed. Because the seat is in the baggage area and because weight in the seat is so far aft it tends to have a very detrimental effect on center of gravity location, most Model 33 and 35 airplanes do not have this seat installed. If you do have this seat, use the occupant's weight and the table to find the moment. Since the seat is fixed to the floor and cannot move fore and aft, there is only one arm for the optional seat.

Model 36 Bonanzas and some Model 35 Bonanzas have optional 5th and 6th seats, with a single block on the form for these seats combined. Note that Model 36, A36 and G36 have a placard limiting the maximum *combined* passenger weight of the 5th and 6th seats, usually limited to 250 lbs. See the placard near the rearmost seats in the individual airplane for the limit that applies to that aircraft. Find the moment of optional-seat occupants using the same table or mathematical methods.

Enter the 3rd/4th and option seat passenger weights and moments onto the loading form (see figure 5).

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION	2372	1945
2. FRONT SEAT OCCUPANTS	330	290
3. 3rd and 4th SEAT OCCUPANTS	280	356
4. 5th SEAT OCCUPANT	0	0

Fig. 5: Including rear seat occupant data

4. Baggage and cargo

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BEECHCRAFT Bonanza F33A
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USEFUL LOAD WEIGHTS AND MOMENTS

BAGGAGE		CARGO	
ARM 150		Fwd of Spar (3rd & 4th Seats Removed) ARM 108	Aft of Spar 3rd,4th, & 5th Seats Removed) ARM 145
WEIGHT	MOM/100	MOM/100	MOM/100
10	15	11	15
20	30	22	29
30	45	32	44
40	60	43	58
50	75	54	73
60	90	65	87
70	105	76	102
80	120	86	116
90	135	97	131
100	150	108	145
110	165	119	160
120	180	130	174
130	195	140	189
140	210	151	203
150	225	162	218
160	240	173	232
170	255	184	247
180	270	194	261
190	285	205	276
200	300	216	290
210	315		305
220	330		319
230	345		334
240	360		348
250	375		363
260	390		377
270	405		392

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Next, account for the baggage you have on board the airplane. Let's say each of the four aboard our sample airplane has 15 pounds of baggage, all of which is secured in the aft baggage compartment. Additionally, there is 10 pounds of aircraft gear in the aft baggage area, and the pilot has a flight bag that weighs seven pounds and is kept behind the front passenger seat, at the feet of the person in the rear, right seat.

Using the Baggage and Cargo table from the POH, you'll find the total moment of the 70 pounds of materials in the aft baggage area is 105. Note the maximum weight permitted in the baggage area, 270 pounds, is the highest weight listed on the table. The flight bag is "forward of the spar" as far as the table is concerned, with an arm of 108 inches; the computed moment is 7 X 108/100 = 7.56, rounded to 8.

Fig. 6: Baggage and cargo table

Enter these weights and moments on the table (see figure 7).

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION	2372	1945
2. FRONT SEAT OCCUPANTS	330	290
3. 3rd and 4th SEAT OCCUPANTS	280	356
4. 5th SEAT OCCUPANT	0	0
5. BAGGAGE	70	105
6. CARGO	7	8

Fig. 7: Including baggage and cargo data

A little more about the baggage/cargo table. If the airplane is flown with the rear seats removed to carry more cargo, use the Forward of Spar column for items in the "well" between the aft carry-through spar and the rear of the front seats, and the Aft of Spar column for weight in the rear floorboards. Be sure to keep the area around the landing gear manual extension crank free so you can crank down the landing gear if needed.

1979 and later A36s and all G36s additionally have a small aft baggage box behind seats 5 and 6. This area is limited to 70 pounds maximum; an additional column appears on the Baggage and Cargo table for those airplanes to provide moment data for baggage in this space.

5. Zero fuel condition

The next step on the loading form is to total all the weights and moments so far, to derive the zero fuel condition. This is the weight and balance of the airplane as you've loaded it but before fuel is accounted for. Knowing this permits you to calculate the maximum amount of fuel you can carry, and has another important use we'll come back to at the end of our calculations. See figure 8.

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION	2372	1945
2. FRONT SEAT OCCUPANTS	330	290
3. 3rd and 4th SEAT OCCUPANTS	280	356
4. 5th SEAT OCCUPANT	0	0
5. BAGGAGE	70	105
6. CARGO	7	8
7. SUBTOTAL ZERO FUEL CONDITION	3059	2704

Fig. 8: Zero fuel condition

6. Fuel loading

Now you can determine the maximum amount of fuel you can carry given your passenger and baggage load. Find your airplane's maximum ramp weight in the Limitations section of the POH. For the sample F33A this limitation is 3412 lbs. Subtract the Zero Fuel Condition weight from the maximum ramp weight to determine the weight allowance remaining—in our example this is 353 lbs. Divide that weight by six to find the number of U.S. gallons that can be loaded and still remain below maximum ramp weight. In our example this comes to 58 gallons, or a little more than ¾ full tanks. Note the Basic Empty Weight of the airplane includes placarded unusable fuel, so unusable fuel is not counted in your derived fuel allowance. You can load up to the full 58 gallons. For purposes of our example let's say you do. Using the POH fuel loading table, and the arm of 75 inches, the moment of 353 lbs./58 gallons of fuel divided by 100 is 264. As a crosscheck, these weights and moments come between the entries for 55 and 60 gallons on the table (see figure 9).

USEFUL LOAD WEIGHTS AND MOMENTS

USABLE FUEL					
LEADING EDGE TANKS ARM 75					
GALLONS	WEIGHT	MOM/100	GALLONS	WEIGHT	MOM/100
5	30	23	44	264	198
10	60	45	50	300	225
15	90	68	55	330	248
20	120	90	60	360	270
25	150	113	65	390	293
30	180	135	70	420	315
35	210	158	74	444	333
40	240	180			

Fig. 9: Fuel loading

Enter these numbers onto the loading table. Total the zero fuel and fuel loading figures to come up with the Ramp Condition, or the weight and balance state of the airplane before engine start (see figure 10). As another crosscheck, if you've added the maximum permissible fuel the Ramp Condition weight will equal the maximum ramp weight.

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION	2372	1945
2. FRONT SEAT OCCUPANTS	330	290
3. 3rd and 4th SEAT OCCUPANTS	280	356
4. 5th SEAT OCCUPANT	0	0
5. BAGGAGE	70	105
6. CARGO	7	8
7. SUBTOTAL ZERO FUEL CONDITION	3059	2704
8. FUEL LOADING	353	264
9. SUBTOTAL RAMP CONDITION	3412	2968

Fig. 10: Fuel load and ramp condition

7. Takeoff condition

You're almost ready to check the weight and balance and center of gravity condition as loaded for takeoff. On the bottom of the loading form you'll see an allowance for fuel burn during engine start, taxi and takeoff (see figure 11). This is meant to help you precisely determine the airplane's fuel load (and the moment of that fuel) at the point the airplane lifts off—when weight and balance becomes important. Note that if you have a very short taxi you may not burn quite as much fuel before liftoff, and the POH provides no guidance. Also, if your engine has been modified, or if you lean aggressively for ground operations, you may have a different fuel burn on the ground. Use your best judgment.

*Fuel for start, taxi, and run up is normally 12 lbs at an average mom/100 of 9.

Fig. 11: Fuel allowance for ground operation

You now have your takeoff condition weight and moment. If you based fuel loading on the maximum available for a given fuel load, the takeoff weight should equal the airplane's maximum gross weight.

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION	2372	1945
2. FRONT SEAT OCCUPANTS	330	290
3. 3rd and 4th SEAT OCCUPANTS	280	356
4. 5th SEAT OCCUPANT	0	0
5. BAGGAGE	70	105
6. CARGO	7	8
7. SUBTOTAL ZERO FUEL CONDITION	3059	2704
8. FUEL LOADING	353	264
9. SUBTOTAL RAMP CONDITION	3412	2968
10.LESS FUEL FOR START, TAXI, RUNUP*	12	9
11.SUBTOTAL TAKEOFF CONDITION	3400	2959

Fig. 12: Takeoff condition

8. Envelope check

Now you can use the computed weight and moment data for your planned flight to see if the airplane is within its certified flight envelope. On the Moment Limits vs. Weight chart (figure 13), compare the airplane's weight (the vertical scale) to the airplane's moment (the sloping lines). The point of intersection is the airplane's c.g. condition with the current load.

An alternate method to use when it's hard to determine whether the result is inside or outside the envelope is to check mathematically. Center of gravity location is the total moment divided by the total weight. Remember we've been dividing the moments by 100, so you'll have to multiply the computed moment by 100 to use this method. In this case the c.g. location is (2959 x 100)/3400, or 87.3. This is 87.3 inches aft of the datum. Look at the bottom of the chart and you'll see the permissible range of c.g. locations for a given weight. At 3400 pounds the forward limit is 82.1 inches aft of datum, and the rear limit is 86.7 inches aft of datum. As loaded, our F33A is outside the approved envelope. We'll need to reduce or adjust the load to be safe, and legal.

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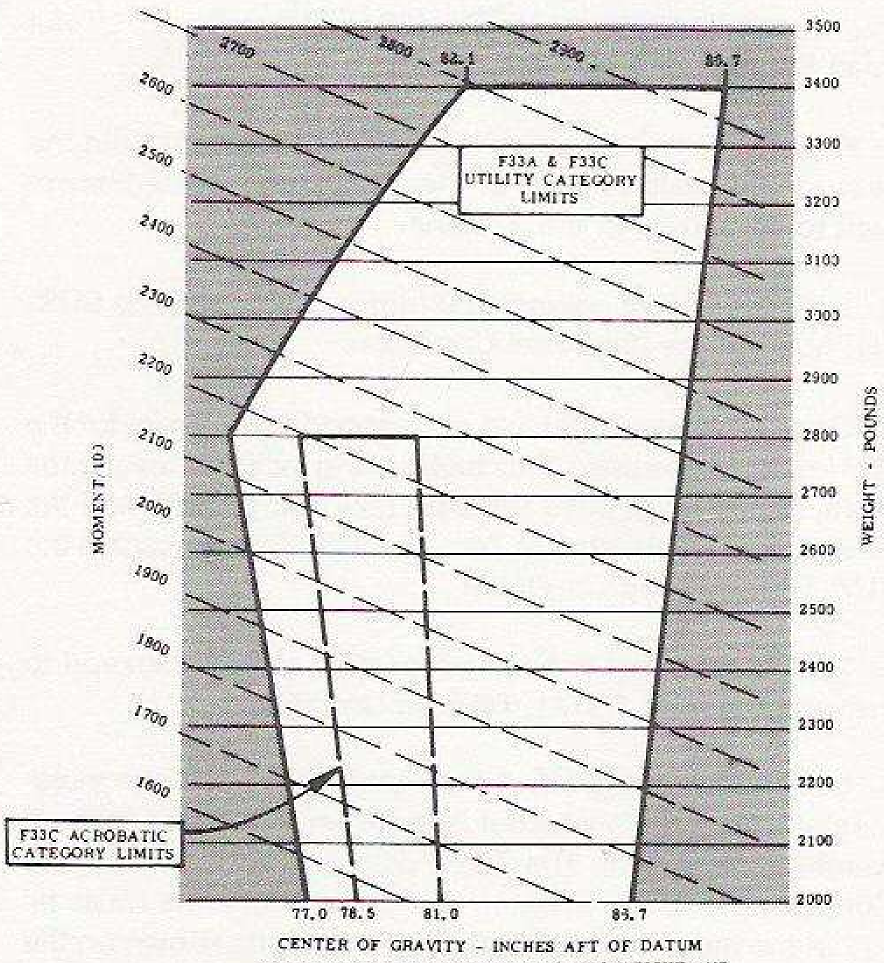
MOMENT LIMITS VS WEIGHT



ENVELOPE BASED ON THE FOLLOWING WEIGHT AND CENTER OF GRAVITY LIMIT DATA (LANDING GEAR DOWN)

	WEIGHT CONDITION	FORWARD C.G. LIMIT	AFT C.G. LIMIT
F33A & F33C UTILITY CATEGORY	3400 LB. (MAXIMUM TAKE-OFF OR LANDING)	82.1	86.7
	2800 LB. OR LESS	77.0	86.7
F33C ACROBATIC CATEGORY	2800 LB. OR LESS	78.5	81.0

Fig. 13: Loading envelope

Let's say after some re-packing, and perhaps even shipping some baggage ahead, you are able to get the total baggage load down to 25 pounds. The new moment for baggage is 37.5, rounded to 38, and your computed loading form now looks like figure 14:

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION	2372	1945
2. FRONT SEAT OCCUPANTS	330	290
3. 3rd and 4th SEAT OCCUPANTS	280	356
4. 5th SEAT OCCUPANT	0	0
5. BAGGAGE	25	38
6. CARGO	7	8
7. SUBTOTAL ZERO FUEL CONDITION	3014	2637
8. FUEL LOADING	353	264
9. SUBTOTAL RAMP CONDITION	3367	2901
10.LESS FUEL FOR START, TAXI, RUNUP*	12	9
11.SUBTOTAL TAKEOFF CONDITION	3355	2892

Fig. 14: Revised loading form

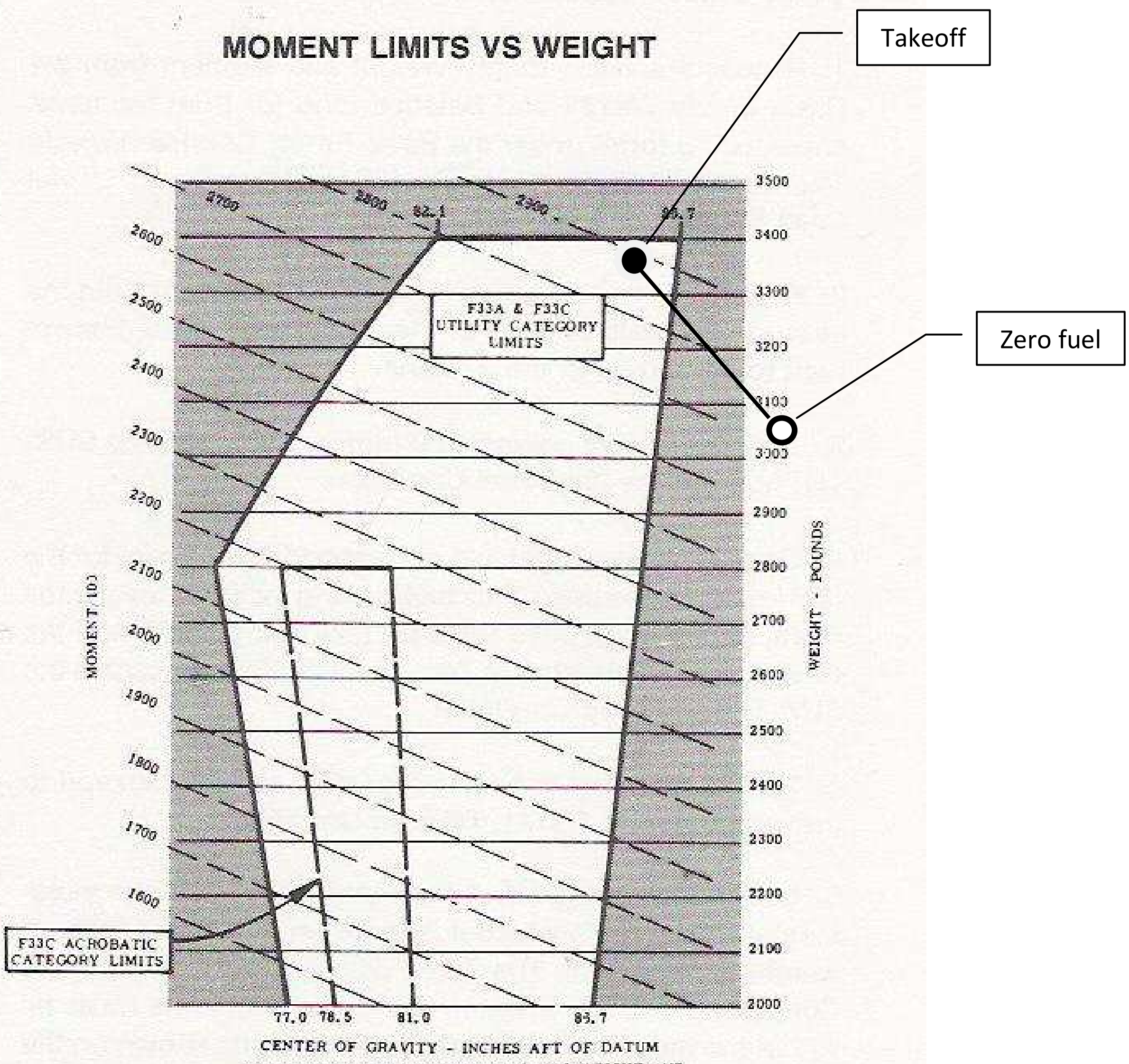
The revised, computed c.g. position for takeoff is (2892 x 100)/3355, or 86.2 inches aft of the datum. It's within limits, near the aft end of the envelope. See figure 15. A filled circle identifies the location of the takeoff condition.

Center of gravity will change with fuel burn. In most factory configurations the c.g. will move aft, toward the rear limit, as fuel is burned. Remember we said you'd use the zero fuel condition again? Using the weight and moment as loaded but without any fuel, you'll have the condition of the airplane if you've flown all the way to fuel exhaustion (except for unusable fuel). Although of course you would not do this "for real," it's a good check to determine whether your range will be limited by center of gravity considerations. Using the zero fuel condition, plot the weight (3014 pounds in our example) and the moment (2637) on the loading envelope chart. This is indicated by an open circle in figure 15. As you can see, the zero fuel condition in this example would be dangerously outside the loading envelope, aft. It would not be safe to fly to the extreme range of the airplane as loaded.

C.G. location follows a straight line derivation in this factory-configuration fuel system. A line drawn from the takeoff condition to the zero fuel condition exits the loading envelope at about 3275 pounds airplane weight. This is 80 pounds below the airplane's takeoff weight; at six pounds per gallon you can only burn about 13 gallons before going outside the approved (and safe) loading envelope. At a very low-power cruise you might be able to fly one hour before you need to be on the ground with minimum fuel reserves. Loaded as we've described, you're fine for a short hop of 100 miles or so, which may be enough to get you to your destination. But if you're traveling farther you'll need to make refueling stops every hour or so, returning fuel load to your original takeoff condition, to stay within the approved loading envelope.

This may be an extreme example, but it was created using actual loading information from a typical F33A, so it is a real consideration at least for some airplanes. It's your job as pilot-in-command to determine the weight and balance limitations that apply to each flight you contemplate.

MOMENT LIMITS VS WEIGHT



ENVELOPE BASED ON THE FOLLOWING WEIGHT AND CENTER OF GRAVITY LIMIT DATA (LANDING GEAR DOWN)

	WEIGHT CONDITION	FORWARD C.G. LIMIT	AFT C.G. LIMIT
F33A & F33C UTILITY CATEGORY	3400 LB. (MAXIMUM TAKE-OFF OR LANDING)	82.1	86.7
	2800 LB. OR LESS	77.0	86.7
F33C ACROBATIC CATEGORY	2800 LB. OR LESS	78.5	81.0

Fig. 15: Loading envelope