# Weight and Balance Control – Helicopter



Weight and balance considerations of a helicopter are similar to those of an airplane, except they are far more critical, and the CG range is much more limited. [Figure 6-1] The engineers who design a helicopter determine the amount of cyclic control power that is available, and establish both the longitudinal and lateral CG envelopes that allow the pilot to load the helicopter so there is sufficient cyclic control for all flight conditions.

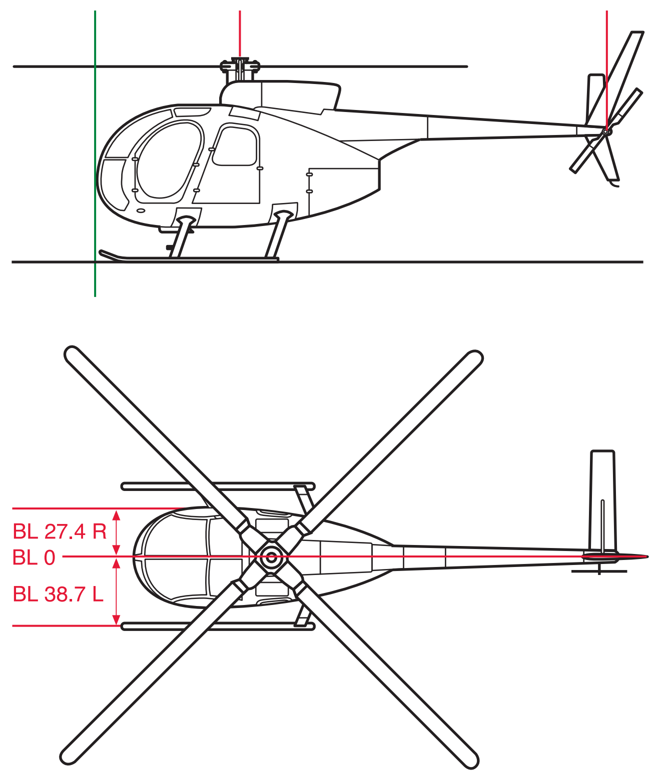


**Figure 6-1.** *Typical helicopter datum, flight stations, and butt line locations.*

If the CG is ahead of the forward limit, the helicopter will tilt, and the rotor disk will have a forward pull. To counteract this, rearward cyclic is required. If the CG is too far forward, there may not be enough cyclic authority to allow the helicopter to flare for a landing, and it will consequently require an excessive landing distance.

If the CG is aft of the allowable limits, the helicopter will fly with a tail-low attitude and may need more forward cyclic stick displacement than is available to maintain a hover in a no-wind condition. There might not be enough cyclic power to prevent the tail boom striking the ground. If gusty winds should cause the helicopter to pitch up during high speed flight, there might not be enough forward cyclic control to lower the nose.

Helicopters are approved for a specific maximum gross weight, but it is not safe to operate them at this weight under all conditions. A high density altitude decrease the safe maximum weight as it affects the hovering, takeoff, climb, autorotation, and landing performance.

The fuel tanks on some helicopters are behind the CG, causing it to shift forward as fuel is used. Under some flight conditions, the balance may shift enough that there will not be sufficient cyclic authority to flare for landing. For these helicopters, the loaded CG should be computed for both takeoff and landing weights.

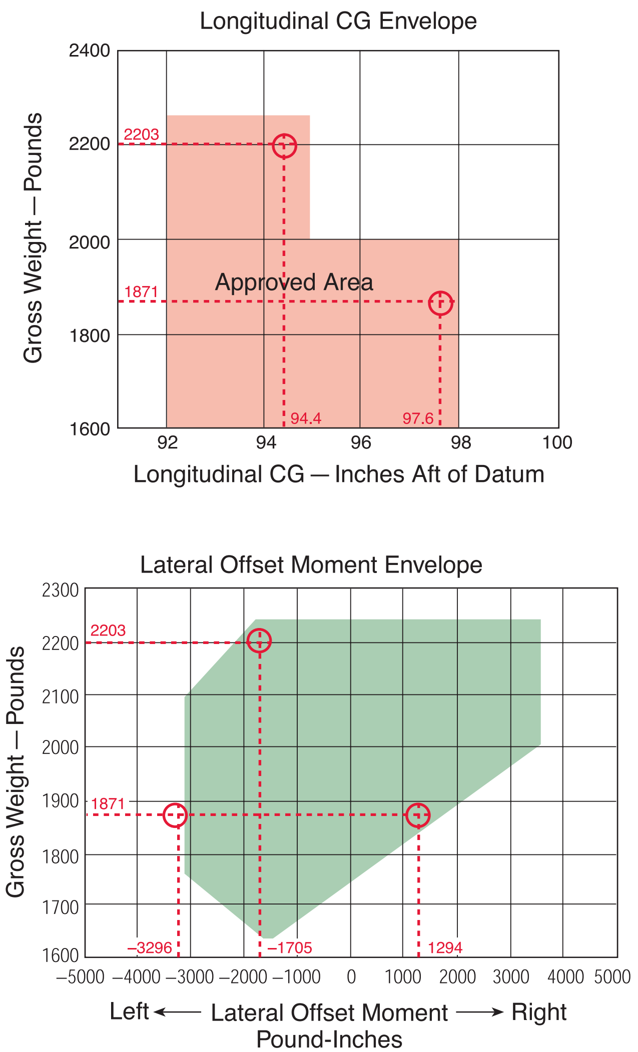


**Figure 6-2.** *Typical helicopter CG envelopes.*

Lateral balance of an airplane is usually of little concern and is not normally calculated. But some helicopters, especially those equipped for hoist operations, are sensitive to the lateral position of the CG, and their POH/AFM include both longitudinal and lateral CG envelopes as well as information on the maximum permissible host load. Figure 6-2 is an example of such CG envelopes.

## Determining the Loaded CG of a Helicopter

The empty weight and empty-weight center of gravity of a helicopter are determined in the same way as for an airplane. The weights recorded on the scales supporting the helicopter are added and their distance from the datum are used to compute the moments at each weighing point. The total moment is divided by the total weight to determine the location of the CG in inches from the datum. The datum of some helicopters is located at the center of the rotor mast, but since this causes some arms to be positive (behind the datum) and others negative (ahead of the datum), most modern helicopters have the datum located ahead of the aircraft, as do most modern airplanes. When the datum is ahead of the aircraft, all longitudinal arms are positive.

The lateral CG is determined in the same way as the longitudinal CG, except the distances between the scales and butt line zero (BL 0) are used as the arms. Arms to the right of BL 0 are positive and those to the left are negative. The Butt line zero (or sometimes referred to as the buttock) is a line through the symmetrical center of an aircraft from nose to tail. It serves as the datum for measuring the arms used to find the lateral CG. Lateral moments that cause the aircraft to rotate clockwise are positive (+), and those that cause it to rotate counter-clockwise are negative (-).

In order to determine whether or not a helicopter with the following specifications is within both longitudinal and lateral weight and balance limits, construct a chart like the one in Figure 6-3:

| Item | Weight | Longitude Arm | Latitude Arm | Longitude Moment | Longitude CG | Lateral Offset Moment |
|---|---|---|---|---|---|---|
| Helicopter empty weight | 1,545 | 101.4 | +0.2 | 156,663 | | 309 |
| Pilot | 170 | 64.0 | –13.5 | 10,880 | | –2,295 |
| Passenger | 200 | 64.0 | +13.5 | 12,800 | | 2,700 |
| Fuel 48 gallons | 288 | 96.0 | –8.4 | 27,648 | | –2,419 |
| | 2,203 | | | 207,991 | 94.4 | –1,705 |

**Figure 6-3.** *Determining the longitudinal CG and the lateral offset moment.*

Empty weight............................................ 1,545 lbs
Empty -weight CG........... 101.4 in. aft of the datum
Lateral balance arm...................0.2 in. right of BL 0
Maximum allowable gross weight............. 2,250 lbs
Pilot.............................170 lbs @64 in. aft of datum and 13.5 in. left of BL 0
Passenger ..................200 lbs @ 64 in. aft of datum and 13.5 in. right of BL 0
Fuel 48 gal .................288 lbs @ 96 in. aft of datum and 84in. left of BL 0

Check the helicopter CG envelopes in Figure 6-2 to determine whether or not the CG is within limits both longitudinally and laterally.

In the longitudinal CG envelope, draw a line vertically upward from the CG of 94.4 inches aft of datum and a horizontal line from the weight of 2,203 pounds gross weight. These lines cross within the approved area.

In the lateral offset moment envelope, draw a line vertically upward from left, or -1,705 lb-in, and a line horizontally from 2,203 pounds on the gross weight index. These lines cross within the envelope, showing the lateral balance is also within limits.

### Effects of Offloading Passengers and Using Fuel

Consider the helicopter in Figure 6-3. The first leg of the flight consumes 22 gallons of fuel, and at the end of this leg, the passenger deplanes. Is the helicopter still within allowable CG limits for takeoff?

To find out, make a new chart like the one in Figure 6-4 to show the new loading conditions of the helicopter at the beginning of the second leg of the flight.

Under these conditions, according to the helicopter CG envelopes in Figure 6-2, the longitudinal CG is within limits. However, the lateral offset moment is excessive since both the pilot and the fuel are on the left side of the aircraft. If the POH allows it, the pilot may fly the aircraft on its second leg from the right-hand seat. According to Figures 6-5 and 6-2, this will bring the lateral balance into limits.

| Item | Weight | Longitude Arm | Latitude Arm | Longitude Moment | Longitude CG | Lateral Offset Moment |
|---|---|---|---|---|---|---|
| Helicopter empty weight | 1,545 | 101.4 | +0.2 | 156,663 | | 309 |
| Pilot | 170 | 64.0 | –13.5 | 10,880 | | –2,295 |
| Fuel 26 gallons | 156 | 96.0 | –8.4 | 14,976 | | –1,310 |
| | 1,871 | | | 182,519 | 97.6 | –3,296 |

**Figure 6-4.** *Determining the longitudinal CG and the lateral offset moment for the second leg of the flight.*

| Item | Weight | Longitude Arm | Latitude Arm | Longitude Moment | Longitude CG | Lateral Offset Moment |
|---|---|---|---|---|---|---|
| Helicopter empty weight | 1,545 | 101.4 | +0.2 | 156,663 | | 309 |
| Pilot | 170 | 64.0 | +13.5 | 10,880 | | 2,295 |
| Fuel 26 gallons | 156 | 96.0 | –8.4 | 14,976 | | –1,310 |
| | 1,871 | | | 182,519 | 97.6 | 1,294 |

**Figure 6-5.** *Determining the longitudinal CG and the lateral offset moment for the second leg of the flight with pilot flying from the right seat.*